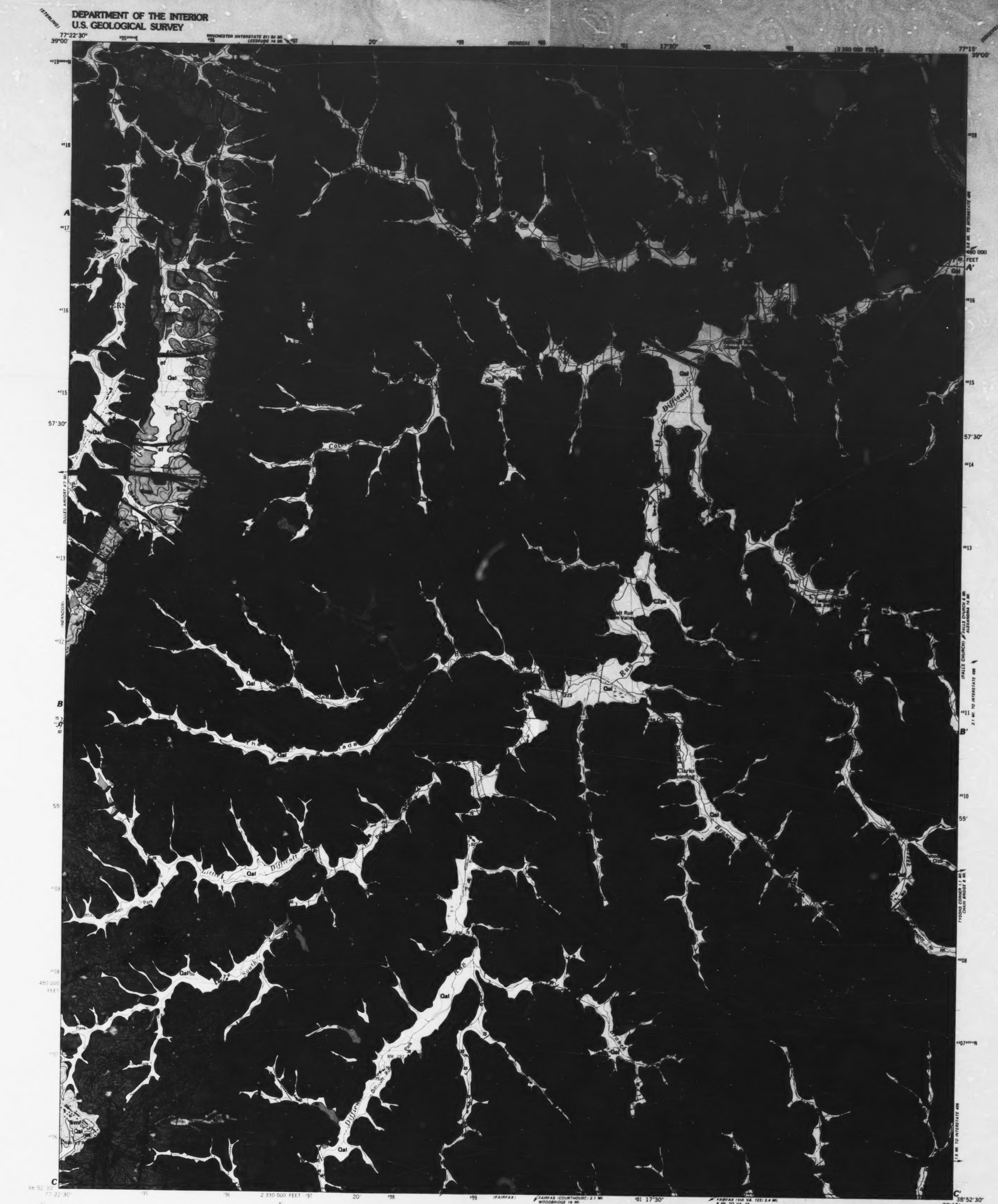
DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY



Base from U.S. Geological Survey, 1967
Photorevision as of 1982
10,000-foot grid based on Virginia coordinate system, north zone

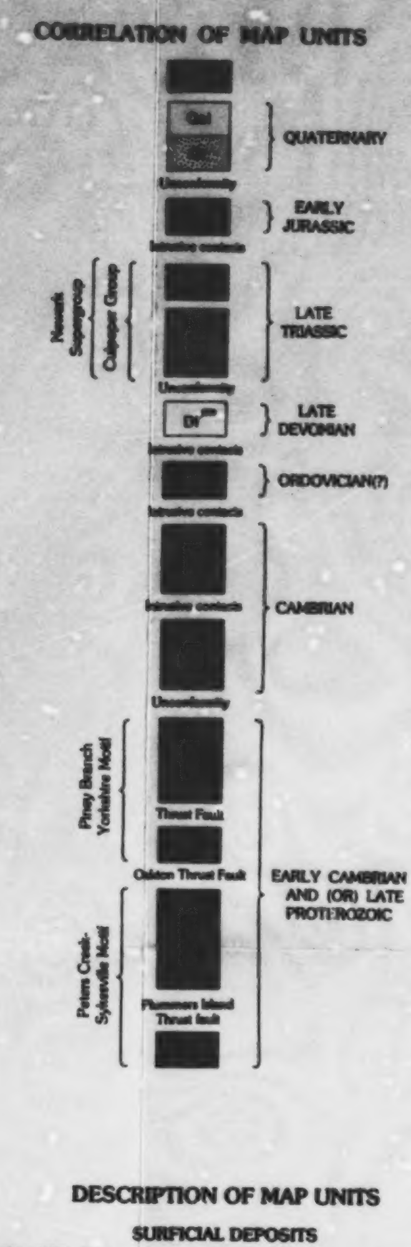
SCALE 1:24 000

CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

QUADRANGLE LOCATION

Crystalline rocks mapped by A.A. Drake, Jr., 1974–76
Mesozoic rocks mapped by K.Y. Lee, 1974
Manuscript approved for publication May 17, 1988

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Artificial fill—Various sandy and gravelly materials; occupies low-lying areas filled for construction of highways, bridges, and railroad beds

Qal **Alluvium (Holocene)**—Sand, gravel, silt, and clay underlying sinuous flood plains along most streams; clastic sediments are in fairly well-bedded, well- to poorly sorted, graded fluvial, cyclic deposits with gravel at base of upward fining sequences; as much as 7 m (23 ft thick). Commonly micaceous silts and sands with quartz and crystalline rock pebbles, cobbles, and boulders in streams draining Piedmont terrain

Qt **Terrace deposits (Holocene (?))**—Gravel, sand, silt, and clay deposits along Potomac River

MESOZOIC ROCKS

Diabase (Early Jurassic)—Medium- to dark-gray; largely equigranular, locally microcrystalline to fine-crystalline near the chilled margins, but coarse-crystalline in central parts of larger bodies. Consists of grayish-green to black crystals of augite and pigeonite and scattered granules or aggregates of magnetite and ilmenite which fill interstices between euhedral and subhedral light-gray plagioclase laths. Forms the Herndon sheet and a dike in the northwestern corner of the quadrangle

Thermally metamorphosed rocks (Late Triassic)—Gray to dark-gray, medium-bluish-gray, and olive-black hornfels and granofels which are metamorphosed sandstone of the Poolesville Member of the Manassas Sandstone. Cordierite hornfels and tourmaline granofels are the major rock types in the metamorphic aureole beneath the Herndon diabase sheet

Poolesville Member of Manassas Sandstone (Late Triassic) (Lee and Froelich, 1989)—Dusky-red to grayish-red to very dark-red, very fine- to medium-grained feldspathic, micaceous, ferruginous sandstone. Thin- to very thick-bedded and massive, and planer crossbedded. Locally it contains lenses and beds of light-gray to gray, medium- to very coarse-grained, feldspathic sandstone and quartzite pebble conglemerate. Thickness is variable but may exceed 1 km (3,281 ft) in places

Reston Member of Manassas Sandstone (Late Triassic) (Lee and Froelich, 1989)—Predominantly pebble to boulder conglomerate containing subangular clasts of schists, quartz, and quartzite in a matrix of fine- to coarse-grained arkosic sand or clayey silt. Contains some beds of micaceous, calcareous, clayey, feldspathic siltstone, fine- to medium-grained crossbedded sandstone; and pebbly, feldspathic, coarse-grained sandstone. In this quadrangle the unit ranges from 3 m (10 ft) to 30 m (98.5 ft) in thickness

PIEDMONT ROCKS

Intrusive Rocks

Dl **Lamprophyre (Late Devonian)**—Fine-grained, dark-greenish-gray, biotite-quartz-plagioclase dike

Bear Island Granodiorite (Ordovician(?)) (Cloos and Cooke, 1953)—Fine-grained, very leucocratic, muscovite-biotite granodiorite and related pegmatite composed largely of quartz, albite, and microcline. Forms small- to moderate-sized sheets and crosscutting bodies. Found only within Peters Creek Schist (€Zps and €CZpg)

Quartz bodies (Cambrian)—Lenticular bodies or irregular masses. Some bodies are foliated or polyfoliated, whereas others are massive

Amphibolite (Lower Cambrian)—Fine- to coarse-grained, greenish-gray

Metasedimentary, Metavolcanic, and Transported Metaigneous Rocks

Station Hills Phyllite Member of Popes Head Formation (Cambrian) (Drake and Lyttle, 1981)—Light-greenish-gray, thin- to medium-bedded pelitic phyllite and lesser very fine-grained metasiltstone and chlorite-rich mafic metatuff. Has an apparent maximum thickness of about 300 m (984 ft)

Old Mill Branch Metasiltstone Member of Popes Head Formation (Cambrian) (Drake and Lyttle, 1981)—Light-greenish-gray, thin- to medium-bedded, medium- to very fine-grained, very mature, micaceous metasiltstone. The metasiltstone contains interbedded pelitic phyllite as well as felsic and mafic metatuff. Unit grades up into Station Hills Phyllite Member €ps), the contact being placed where more than 75 percent of the beds are pelitic phyllite. Unit has a maximum thickness of about 730 m (2,395 ft)

Piney Branch Complex (Early Cambrian and (or) Late Proterozoic) (Drake and Morgan, 1981)—Intermixed complex consisting of subequal parts of peridotite, pyroxenite, and gabbro now represented by serpentinite, soapstone, actinolite schist, and metagabbro which constitute an autoclastic melange. Contains small sheets and dikes of quartz-albite plagiogranite (€Zp)

Yorkshire Formation (Early Cambrian and (or) Late Proterozoic) (Drake and Morgan, 1981)—Polygenetic melange consisting of a dark quartz-plagioclase-chlorite granofels matrix which contains chips, fragments, and small blocks of quartz, serpentinite, metagabbro, plagiogranite, mafic volcanics, and other exotic rock types. Characterized by abundant light-colored feldspar grains which contrast greatly with the dark phyllosilicate component, as well as by a scaly foliation

Peters Creek Schist (Early Cambrian and (or) Late Proterozoic) (Drake and Morgan, 1981)—Fine- to coarse-grained, lustrous, greenish-gray to gray, reddish-weathering, quartz-rich schist, and lesser mica gneiss. Fine- to medium-grained, light- to medium-gray, yellowish- to reddish-brown-weathering, well-bedded metagraywacke and semi-pelitic schist (€Zpg). Both of these rock types contains abundant interbeds of the other rock type, as well as a few layers of calc-silicate rock. Much of the graywacke is graded, but some beds have a pseudolamination which is actually pressure-solution cleavage. Contains large mappable blocks of serpentinite and associated chlorite- tremolite-epidote schist, talc-chlorite schist, and talc-chlorite-actinolite schist (€Zu). The unit's thickness is not known, as its base is marked by the Plummers Island thrust fault (Drake, 1985a). It is overlain on the west by Triassic rocks

Sykesville Formation (Early Cambrian and (or) Late Proterozoic) (Hopson, 1964; Drake, 1985a)—Light- to medium-gray, medium-grained sedimentary melange consisting of a quartzofeldspathic matrix that contains fragments of foliated felsic and mafic metavolcanic rocks, quartz, metagabbro, Peters Creek Schist, and ultramafic rocks. Shown in cross section only

EXPLANATION OF MAP SYMBOLS

Contact—Dotted where concealed. Distribution and concentration of structural symbols indicates degree of reliability

Faults—dotted where concealed

High angle—U, upthrown side; D, downthrown side, where known

Thrust—Sawteeth on upper plate

Overturned thrust—Sawteeth in direction of dip; bar on tectonically higher plate

FOLDS

(Dotted where concealed)

Fold phases are designated from oldest to youngest, CH, Captain Hickory; P, Potomac; R, Reston; C, Clifton; A, Accotink Creek

Anticline—Showing crest line and direction of plunge

Overturned anticline—Showing trace of axial surface, direction of dip of limbs, and direction of plunge

Antiform—Showing crest line and direction of plunge where known

Overturned antiform—Showing trace of axial surface, direction of dip of limbs, and direction of plunge

Syncline—Showing trough line and direction of plunge

Overturned syncline—Showing trace of axial surface, direction of dip of limbs, and direction of plunge

Synform—Showing trough line and direction of plunge

Overturned synform—Showing trace of axial surface, direction of dip of limbs, and direction of plunge

Overturned fold, direction of closure unknown—Showing trace of axial surface and direction of dip of limbs.

MINOR FOLDS

Minor asymmetric fold—Showing bearing and plunge of axis and rotation sense viewed down plunge

Minor anticline—Showing bearing and plunge of axis

PLANAR FEATURES

(May be combined with linear features)

Strike and dip of beds— Ball indicates top known from sedimentary structures

- Inclined
- Overturned
- Vertical

Strike and dip of foliation—Rocks of the Piney Branch Complex and Yorkshire Formation, and schistosity of indeterminate generation in other rocks

- Inclined
- Vertical

Strike and dip of phyllonitic foliation

- Inclined
- Vertical

Strike and dip of transposition foliation

- Inclined
- Vertical

Strike and dip of schistosity

- Inclined
- Vertical

Strike and dip of spaced schistosity

- Inclined
- Vertical

Strike and dip of crenulation cleavage or schistosity

- Inclined

Strike and dip of joints

- Inclined
- Vertical

LINEAR FEATURES

(May be combined with planar features)

Bearing and plunge of mineral lineations

Bearing and plunge of intersections of bedding and schistosity

Bearing and plunge of microfolds in schistosity

Bearing and plunge of intersection of crenulation cleavage and schistosity

OTHER FEATURES

⚒ **Quarry**

INTRODUCTION

The Vienna 7.5-minute quadrangle is largely in north-central Fairfax County, Virginia but the extreme northeast corner is in Montgomery County, Maryland. Much of the quadrangle is urban, and development is proceeding rapidly throughout the area. Piedmont crystalline rocks of the central Appalachian internides underlie most of the quadrangle. Mesozoic sedimentary and intrusive igneous rocks crop out in the northwestern part of the quadrangle. Alluvium occurs along most streams and gravel terrace deposits occur along the Potomac River. Natural outcrops, many of which are saprolite, are largely restricted to stream valleys. Drake's knowledge of the northern Virginia crystalline rocks has been gained by abundant work in recent years (Drake, 1985a, 1985b, 1985c; 1986a, 1986b, 1986c; 1987; Drake and Froelich, 1986; Drake and Lyttle, 1981; Drake and Morgan, 1981, 1983; and Drake and others, 1979). Knowledge of the Mesozoic rocks was gained by the work of Drake and others (1979) and particularly by Lee and Froelich (1989). This work is briefly summarized below.

CRYSTALLINE ROCKS

Metamorphosed sedimentary rocks constitute most of the crystalline terrane in the Vienna quadrangle, but some volcanic and intrusive rocks are also present. Transported intrusive rocks are also fairly abundant. These rocks have been intruded by small bodies of Bear Island Granodiorite (Cloos and Cooke, 1953), quartz bodies, and one lamprophyre dike.

METASEDIMENTARY AND METAVOLCANIC ROCKS

The metasedimentary and metavolcanic rocks in this part of northern Virginia constitute a stack of four lithotectonic units (Drake and Lyttle, 1981; Drake and Morgan, 1981; Drake, 1985c, 1987). The youngest and highest of these units, the Popes Head Formation, unconformably overlies all the other units that constitute three thrust sheet-precursory melange pairs termed tectonic motifs (Drake, 1985a, 1985c). These motifs are, from highest to lowest, the Piney Branch-Yorkshire, the Peters Creek-Sykesville, and the Annandale-Indian Run. Only the Piney Branch-Yorkshire and the Peters Creek part of the Peters Creek-Sykesville motifs crop out in the Vienna quadrangle.

POPES HEAD FORMATION

The Popes Head Formation (Drake and Lyttle, 1981) unconformably overlies all the other lithotectonic units and consists of a lower Old Mill Branch Metasiltstone Member and an upper Station Hills Phyllite Member. Both members contain interbedded felsic and mafic metatuff. These rocks are interpreted to belong to Bouma's (1962) turbidite sequence T_{de} and to Mutti and Ricci Lucchi's (1978) turbidite facies D, suggesting deposition from weak turbidity flows (Drake and Lyttle, 1981). Drake and Lyttle (1981) have suggested that the formation may have resulted from the bilateral filling of a back-arc basin. Rocks of the Popes Head Formation contain the typical mineral assemblage of quartz-muscovite-biotite-plagioclase-chlorite, and the unit is at the biotite grade of metamorphism.

PINEY BRANCH—YORKSHIRE MOTIF

The Piney Branch Complex has been interpreted to be a fragment of a large dismembered ophiolite (Drake and Morgan, 1981). This complex lacks discernible order and is thought to be a tectonic melange resulting from the autoclastic deformation of a layered complex that contained repetitive cycles of ultramafic and mafic layers (Drake and Morgan, 1981). Mineralogic and chemical data for these rocks are presented in Drake and Morgan (1981). The ultramafic and mafic rocks within the complex have been retrogressively metamorphosed to mineral assemblages stable in the greenschist facies, and almost no original minerals survive. These ultramafic and mafic rocks are intruded by small dikes and sheets of leucocratic rocks having a color index of less than 2. They are composed of quartz and plagioclase and have Na_2O-K_2O ratios of more than 4 to 1. The petrographic and chemical data indicate that these rocks are similar to the metamorphosed plagiogranites of the Baltimore Complex of Maryland (Morgan, 1977) and to plagiogranites in other ophiolite complexes (Coleman and Peterman, 1975).

The Yorkshire Formation, a sedimentary melange, forms a thin discontinuous lower border to the Piney Branch Complex. It is interpreted to be a precursory melange to the Piney Branch Complex (Drake and Morgan, 1981). The Yorkshire contains mineral assemblages stable in the greenschist facies of regional metamorphism.

The Yorkshire and the overlying Piney Branch Complex constitute the highest tectonic motif in northern Virginia. The main mass of the motif extends from the southernmost part of the Vienna quadrangle to Bull Run in the Manassas 7.5-minute quadrangle (Drake and others, 1979). Two smaller masses occur a short distance to the northeast, and two even smaller masses crop out farther to the northeast in Vienna City. The motif is thought to have had a multiple movement history which involved the subaqueous emplacement of the Piney Branch upon the Yorkshire and the later thrusting of this assemblage onto the Peters Creek Schist (Drake and Morgan, 1981). The discontinuous nature of the Yorkshire is thought to reflect partial shearing out during the late thrust event. The Piney Branch-Yorkshire motif overlies the Peters Creek-Sykesville motif on the Oakton thrust fault.

PETERS CREEK—SYKESVILLE MOTIF

The Peters Creek Schist (Drake and Morgan, 1981) consists of quartz-rich schist and graywacke interpreted to be a turbidite deposited under fairly high energy conditions in a large submarine fan (Drake and Morgan, 1981). In northern Virginia and adjacent Maryland, the Peters Creek characteristically contains large blocks of ultramafic rocks (Drake and others, 1979; Froelich, 1975). In northern Virginia contact relations suggest that the ultramafic rocks are olistoliths, as do some exposures in Montgomery County, Maryland (Drake and Morgan, 1983). Ultramafic bodies are characteristic of the Peters Creek Schist as far to the northeast as the Philadelphia area, as well as probable correlative rocks southwest of the Culpeper basin (Drake and others, in press; Rankin and others, in press). It is impossible at this time to evaluate how many of these bodies are olistoliths and how many may result from tectonic emplacement. These bodies have folds not present in the surrounding schists, so they were deformed prior to emplacement. In any case, the Peters Creek Schist is a type of ophiolitic melange that was probably deposited on or adjacent to oceanic crust. The Peters Creek constitutes a major part of the Potomac terrane in the central Appalachians (Drake, 1985b).

The Peters Creek Schist is polymetamorphic. It has undergone a prograde event that ranges from chlorite grade in the west to sillimanite grade in the east (Fisher, 1963, 1970; Drake and others, 1979; Drake and Morgan, 1981; Drake, 1985b, 1986a, 1986c). About coincident with the appearance, in both time and space, of sillimanite, the rocks became migmatitic. Near Sherwin Island in the Potomac River, about 1.5 km (0.9 miles) east of the Vienna quadrangle (Drake and others, 1979, Drake and Morgan, 1981), the highest-grade rocks and migmatites become severely sheared and are retrogressively metamorphosed to chlorite-sericite phyllonites. A later metamorphic event is recognized in these rocks in which chloritoid has grown within shimmer aggregate pseudomorphs of staurolite, andalusite, and garnet.

The Peters Creek Schist overlies the Sykesville Formation, the precursory melange of the Peters Creek-Sykesville motif on the Plummers Island thrust fault (Drake, 1985a, 1986a). The Sykesville does not crop out in the Vienna quadrangle, and the reader is referred to Drake (1985a), Drake and Lyttle (1981), and Drake and Morgan (1981) for a description of that unit and its relation to the Peters Creek Schist.

PRE-MESOZOIC INTRUSIVE ROCKS

The metasedimentary and metavolcanic rocks in the Vienna quadrangle contain sills of amphibolite, small bodies of Bear Island Granodiorite, one lamprophyre dike, and a few quartz bodies.

AMPHIBOLITE

Sills of epidote-plagioclase-hornblende amphibolite intrude the Peters Creek Schist. Some specimens contain relict clinopyroxene and have diabase textures. These sills are almost certainly metadiabase. Although foliated, only the smaller sills and the margins of the larger sills are schistose. We have only recently become aware of unpublished radiometric determinations on zircon from amphibolite on the southeastern tip of Bear Island in the Falls Church quadrangle (Fisher, 1971). These determinations gave a Pb^{207}-Pb^{206} age of 525±60 Ma, and a concordia age of 550 Ma, assuming continuous diffusion. Although there is a large error bar, these dates are consistent with the regional geology and the amphibolite is considered to be of Early Cambrian age. The sills appear to be restricted to rocks of the staurolite + andalusite or higher grade zones, suggesting that they were emplaced during metamorphism.

QUARTZ BODIES

Lenticular to irregularly shaped bodies of quartz occur within both the Peters Creek Schist and Popes Head Formation. It is impossible to date these bodies, but they are interpreted to result from metamorphic differentiation within the regime of greenschist-facies metamorphism. The bodies within the Peters Creek Schist probably formed during both the early prograde and retrograde events. The body within the Popes Head Formation is interpreted to date from the prograde metamorphic event experienced by that unit.

BEAR ISLAND GRANODIORITE

Leucocratic granitoid rock forms dikes, sheets, and small irregularly shaped intrusive bodies within the high-grade part of the Peters Creek Schist from Bear Island in the Potomac River south to the overlap of Mesozoic rocks in the Manassas quadrangle (Drake and others, 1979). Similar rocks have been recognized at least as far northeast as the Patuxent River in the Woodbine 7.5-minute quadrangle in Maryland (A.A. Drake, Jr., unpub. data). The composition of these rocks varies, and they have been termed granodiorite, leucotonalite, adamellite, quartz diorite, and quartz monzonite. Cloos and Cook (1953) formally named these intrusive rocks the Bear Island Granodiorite. Hopson (1964) called the suite Bear Island Granite because of its silicic composition and because its plagioclase is albite; Drake (1986a, 1987) followed Hopson's usage. Modal data (fig. 1) are equally divided between the monzogranite, granodiorite, and tonalite fields. Most of the monzogranites, however, plot near the granodiorite field and petrographically, granodiorite appears to be the best name for these rocks. Chemically (table 1), however, most of the rocks are trondhjemite (fig. 2), and closely resemble the oceanic trondhjemites of Fiji (Gill and Stork, 1979). In any case, granodiorite appears to be the most useful rock name, although the Bear Island rocks contain more Na_2O and much less K_2O and MgO than typical granodiorites (Nockolds, 1954). More work needs to be done on these interesting rocks, but such a study will be hindered by the difficulty of finding suitable material away from the Potomac River. The name Bear Island Granodiorite is herein accepted for use by the U.S. Geological Survey.

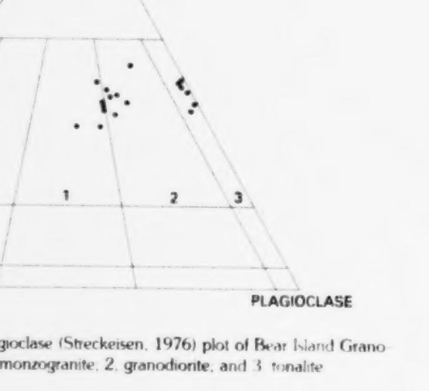


Figure 1.—Quartz-alkali feldspar plagioclase (Streckeisen, 1976) plot of Bear Island Granodiorite. Represented fields are: 1, monzogranite; 2, granodiorite, and 3, tonalite

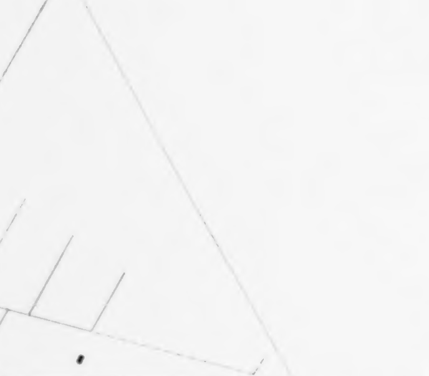


Figure 2.—Normative feldspar (O'Connor, 1965) plot of Bear Island Granodiorite. Represented fields are: 1, trondhjemite; 2, granite; and 3, tonalite.

Table 1.—Chemical analyses and C.I.P.W. norms of the Bear Island Granodiorite (weight percent)

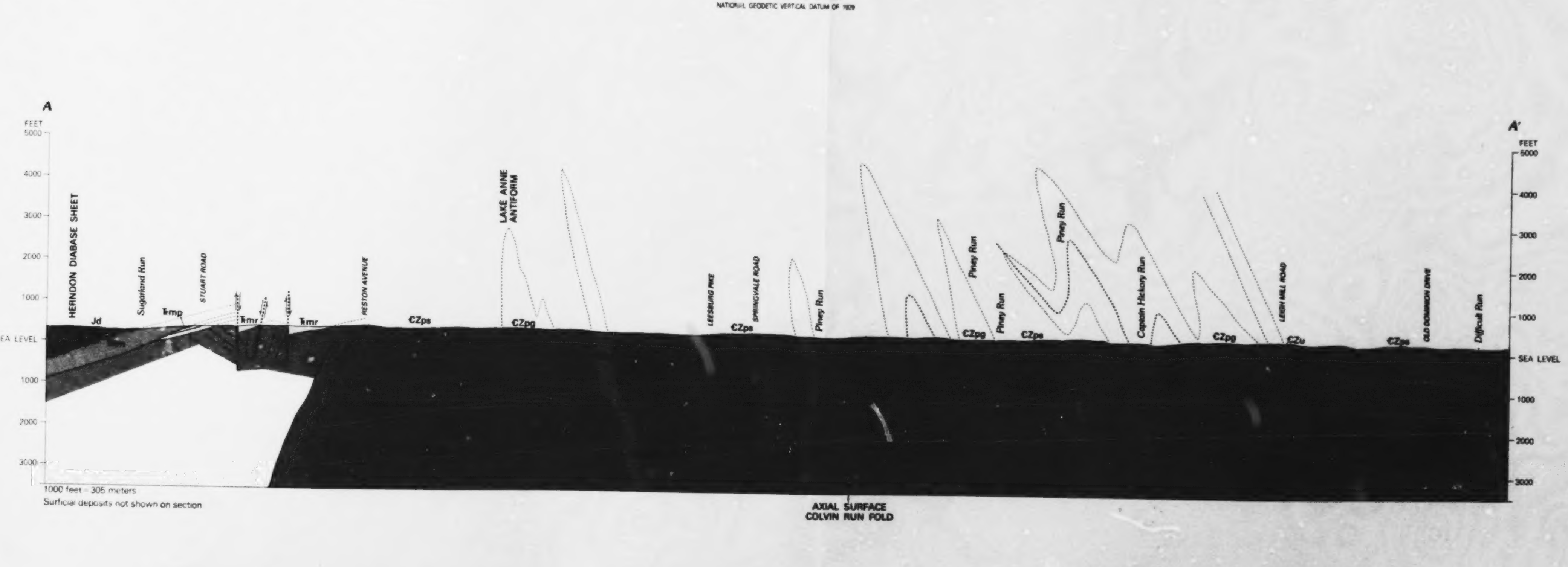
Sample No.	1	2	3	4	5	6	7	8	9	10	11
SiO_2	74.9	76.6	75.5	76.2	74.0	58.1	68.4	77.2	75.4	74.0	77.01
Al_2O_3	14.2	14.3	14.7	13.5	13.8	25.5	18.5	13.3	13.8	14.5	13.47
Fe_2O_3	1.9	0.51	0.32	0.8	0.32	0.13	0.65	0.13	0.29	0.73	0.48
FeO	0.16	0.20	0.40	0.36	0.24	0.88	0.32	0.7	0.24	0.20	1.15
MgO	0.17	0.20	0.18	0.37	0.29	0.36	0.42	0.29	0.19	0.15	0.15
CaO	1.3	0.31	0.81	1.2	0.95	6.5	2.4	0.22	0.62	0.66	0.53
Na_2O	3.9	5.1	5.1	3.4	3.1	6.7	6.6	4.4	3.1	6.1	3.69
K_2O	1.9	1.5	1.6	2.2	5.5	0.7	0.88	2.0	5.2	1.4	2.18
H_2O+	0.65	0.6	0.88	0.76	0.14	0.72	0.62	0.74	0.59	0.52	0.89
H_2O-	0.09	0.11	0.11	0.12	0.86	0.1	0.14	–	–	0.21	0.01
TiO_2	0.04	0.08	0.08	0.19	0.11	0.17	0.19	0.09	0.07	0.04	0.10
P_2O_5	0.21	0.08	0.2	–	0.11	0.11	0.11	0.14	0.1	0.12	0.06
MnO	0.06	0.08	0.04	0.08	0.10	0.1	0.07	0.06	0.03	0.04	0.13
CO_2	.41	0.05	0.05	0.26	0.08	0.08	0.05	0.05	0.05	0.04	0.13
Total	99.89	99.72	99.97	99.44	99.60	100.15	99.35	99.32	98.68	98.71	99.98
C.I.P.W. Norms (weight percent)											
Quartz	42.7	41.7	38.2	46.6	32.6	1.4	21.5	43.3	36.5	32.6	45.8
Orthoclase	11.1	8.9	9.4	12.8	33.4	3.9	5.6	11.7	30.6	8.3	12.8
Albite	34.1	43.0	44.0	29.3	27.2	57.6	56.6	38.2	26.2	52.4	31.4
Anorthite	5.6	0.6	3.1	5.8	3.9	32.0	11.1	0.8	3.3	2.5	2.5
Corundum	3.7	4.2	3.5	3.5	1.1	2.0	2.6	3.6	1.9	2.1	4.2
Diopside	0.4	0.5	0.8	1.0	0.8	2.3	1.1	1.9	0.5	0.4	2.2
Wollastonite	–	–	–	–	–	–	–	–	–	–	–
Hypersthene	–	–	–	–	–	–	–	–	–	–	–
Magnetite	0.7	0.7	0.5	0.7	0.5	0.2	0.5	0.2	0.5	0.7	0.7
Apatite	0.3	0.3	0.3	–	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Ilmenite	–	0.2	0.2	0.5	0.2	0.3	0.5	0.2	0.2	0.3	0.2
Titanite	–	–	–	–	–	–	–	–	–	–	–
Hematite	1.4	–	–	0.3	–	–	0.3	–	–	0.2	–
Total	100.0	100.1	100.0	100.5	100.0	100.0	100.1	100.2	100.0	99.8	100.1

Rapid rock analyses by P. Elmore, S. Botts, H. Smith, G. Chloe, J. Kelsey, J. Glenn, and L. Artis, USGS, Samples 1–7; P. Elmore, I.H. Barlow, S. Botts, and G. Chloe, USGS, Samples 8–9; and K. Coates and H. Smith, USGS, (Sample 10). Sample 11 from Hopson (1964).

Description of samples

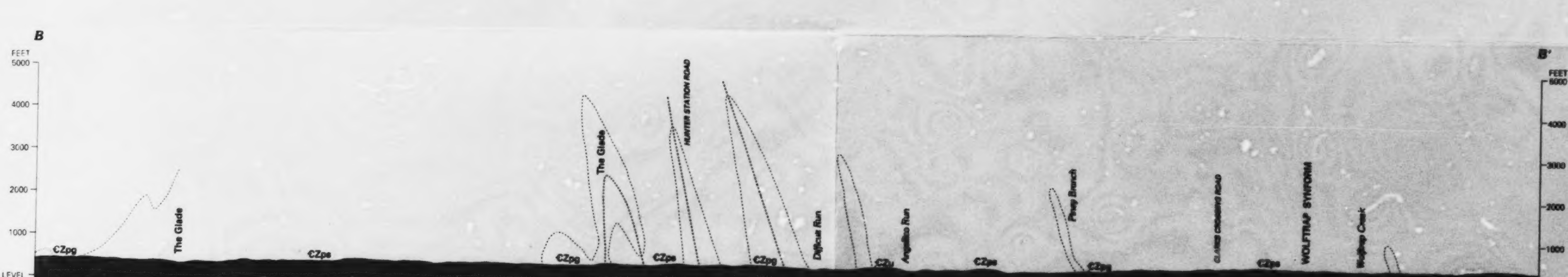
All samples from the Falls Church 7.5-minute quadrangle except when noted

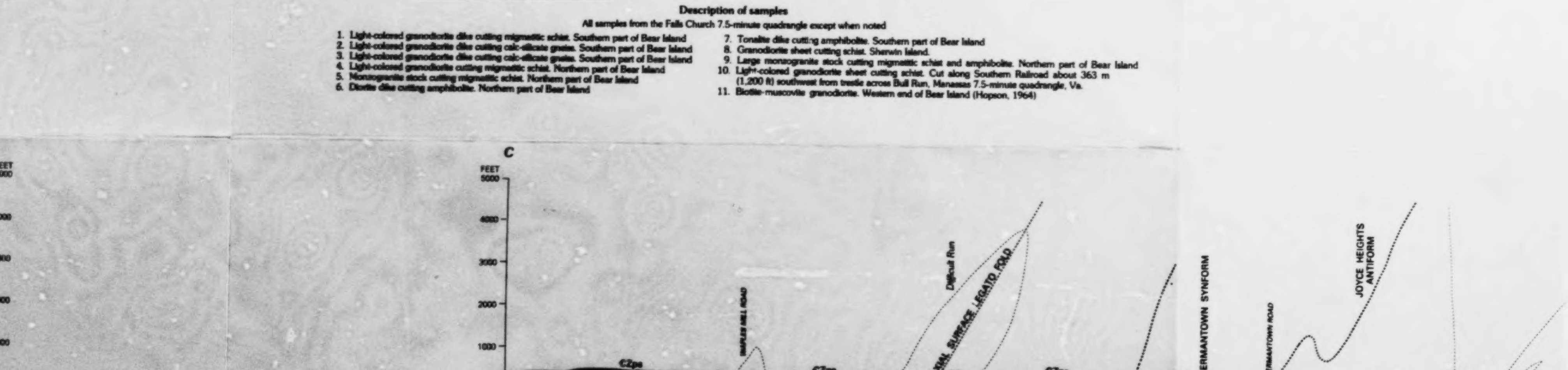
1. Light-colored granodiorite dike cutting migmatitic schist. Southern part of Bear Island
2. Light-colored granodiorite dike cutting calc-silicate gneiss. Southern part of Bear Island
3. Light-colored granodiorite dike cutting calc-silicate gneiss. Southern part of Bear Island
4. Light-colored granodiorite cutting migmatitic schist. Northern part of Bear Island
5. Monzogranite stock cutting migmatitic schist. Northern part of Bear Island
6. Diorite dike cutting amphibolite. Northern part of Bear Island
7. Tonalite dike cutting amphibolite. Southern part of Bear Island
8. Granodiorite sheet cutting schist. Sherwin Island.
9. Large monzogranite stock cutting migmatitic schist and amphibolite. Northern part of Bear Island
10. Light-colored granodiorite sheet cutting schist. Cut along Southern Railroad about 363 m (1,200 ft) southwest from trestle across Bull Run, Manassas 7.5-minute quadrangle, Va.
11. Biotite-muscovite granodiorite. Western end of Bear Island (Hopson, 1964)



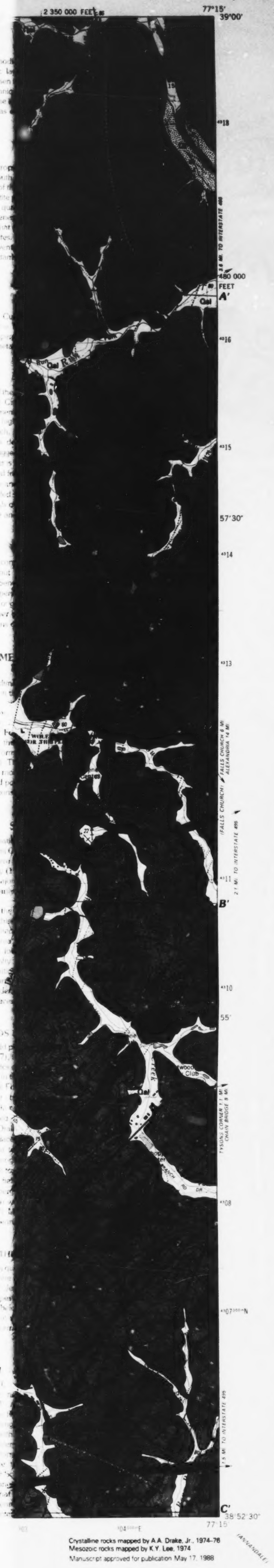
1000 feet = 305 meters
Surficial deposits not shown on section

AXIAL SURFACE
COLVIN RUN FOLD



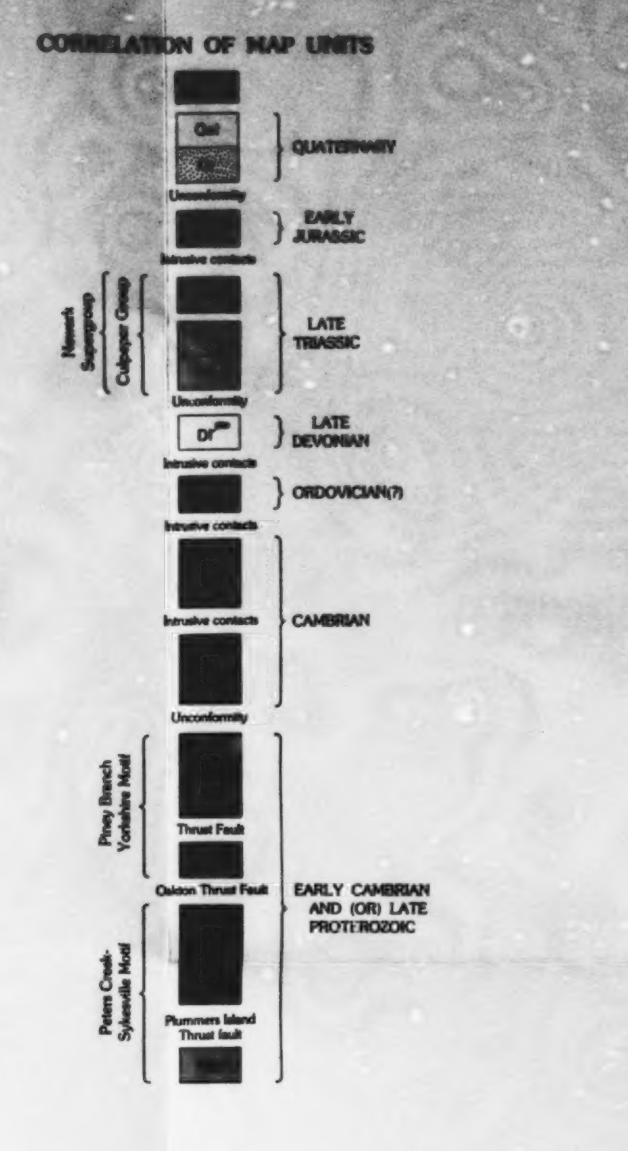


GEOLOGIC QUADRANGLE MAP
VIENNA QUADRANGLE, VA.–MD.
GQ–1670



Crystalline rocks mapped by A.A. Drake, Jr., 1974–78
Mesozoic rocks mapped by K.Y. Lee, 1974
Manuscript approved for publication May 17, 1988

CORRELATION OF MAP UNITS



DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Artificial fill—Various sandy and gravelly materials; occupies low-lying areas filled for construction of highways, bridges, and railroad beds

Qal **Alluvium (Holocene)**—Sand, gravel, silt, and clay underlying sinuous flood plains along most streams; clastic sediments are in fairly well-bedded, well- to poorly sorted, graded fluvial, cyclic deposits with gravel at base of upward fining sequences; as much as 7 m (23 ft thick). Commonly micaceous silts and sands with quartz and crystalline rock pebbles, cobbles, and boulders in streams draining Piedmont terrain

Qt **Terrace deposits (Holocene (?))**—Gravel, sand, silt, and clay deposits along Potomac River

MESOZOIC ROCKS

Diabase (Early Jurassic)—Medium- to dark-gray; largely equigranular, locally microcrystalline to fine-crystalline near the chilled margins, but coarse-crystalline in central parts of larger bodies. Consists of grayish-green to black crystals of augite and pigeonite and scattered granules or aggregates of magnetite and ilmenite which fill interstices between euhedral and subhedral light-gray plagioclase laths. Forms the Herndon sheet and a dike in the northwestern corner of the quadrangle

Thermally metamorphosed rocks (Late Triassic)—Gray to dark-gray, medium-bluish-gray, and olive-black hornfels and granofels which are metamorphosed sandstone of the Poolesville Member of the Manassas Sandstone. Cordierite hornfels and tourmaline granofels are the major rock types in the metamorphic aureole beneath the Herndon diabase sheet

Ћmp **Poolesville Member of Manassas Sandstone (Late Triassic) (Lee and Froelich, 1989)**—Dusky-red to grayish-red to very dark-red, very fine- to medium-grained feldspathic, micaceous, ferruginous sandstone. Thin- to very thick-bedded and massive, and planar crossbedded. Locally it contains lenses and beds of light-gray to gray, medium- to very coarse-grained, feldspathic sandstone and quartzite pebble conglomerate. Thickness is variable but may exceed 1 km (3,281 ft) in places

Ћmr **Reston Member of Manassas Sandstone (Late Triassic) (Lee and Froelich, 1989)**—Predominantly pebble to boulder conglomerate containing subangular clasts of schists, quartz, and quartzite in a matrix of fine- to coarse-grained arkosic sand or clayey silt. Contains some beds of micaceous, calcareous, clayey, feldspathic siltstone, fine- to medium-grained crossbedded sandstone; and pebbly, feldspathic, coarse-grained sandstone. In this quadrangle the unit ranges from 3 m (10 ft) to 30 m (98.5 ft) in thickness

PIEDMONT ROCKS

Intrusive Rocks

Dl **Lamprophyre (Late Devonian)**—Fine-grained, dark-greenish-gray, biotite-quartz-plagioclase dike

Bear Island Granodiorite (Ordovician(?)) (Cloos and Cooke, 1953)—Fine-grained, very leucocratic, muscovite-biotite granodiorite and related pegmatite composed largely of quartz, albite, and microcline. Forms small- to moderate-sized sheets and crosscutting bodies. Found only within Peters Creek Schist (€Zps and €CZpg)

Quartz bodies (Cambrian)—Lenticular bodies or irregular masses. Some bodies are foliated or polyfoliated, whereas others are massive

Amphibolite (Lower Cambrian)—Fine- to coarse-grained, greenish-gray

Metasedimentary, Metavolcanic, and Transported Metaigneous Rocks

Station Hills Phyllite Member of Popes Head Formation (Cambrian) (Drake and Lyttle, 1981)—Light-greenish-gray, thin- to medium-bedded pelitic phyllite and lesser very fine-grained metasiltstone and chlorite-rich mafic metatuff. Has an apparent maximum thickness of about 300 m (984 ft)

Old Mill Branch Metasiltstone Member of Popes Head Formation (Cambrian) (Drake and Lyttle, 1981)—Light-greenish-gray, thin- to medium-bedded, medium- to very fine-grained, very mature, micaceous metasiltstone. The metasiltstone contains interbedded pelitic phyllite as well as felsic and mafic metatuff. Unit grades up into Station Hills Phyllite Member €ps), the contact being placed where more than 75 percent of the beds are pelitic phyllite. Unit has a maximum thickness of about 730 m (2,395 ft)

Piney Branch Complex (Early Cambrian and (or) Late Proterozoic) (Drake and Morgan, 1981)—Intermixed complex consisting of subequal parts of peridotite, pyroxenite, and gabbro now represented by serpentinite, soapstone, actinolite schist, and metagabbro which constitute an autoclastic melange. Contains small sheets and dikes of quartz-albite plagiogranite (€Zp)

Yorkshire Formation (Early Cambrian and (or) Late Proterozoic) (Drake and Morgan, 1981)—Polygenetic melange consisting of a dark quartz-plagioclase-chlorite granofels matrix which contains chips, fragments, and small blocks of quartz, serpentinite, metagabbro, plagiogranite, mafic volcanics, and other exotic rock types. Characterized by abundant light-colored feldspar grains which contrast greatly with the dark phyllosilicate component, as well as by a scaly foliation

Peters Creek Schist (Early Cambrian and (or) Late Proterozoic) (Drake and Morgan, 1981)—Fine- to coarse-grained, lustrous, greenish-gray to gray, reddish-weathering, quartz-rich schist, and lesser mica gneiss. Fine- to medium-grained, light- to medium-gray, yellowish- to reddish-brown-weathering, well-bedded metagraywacke and semi-pelitic schist (€Zpg). Both of these rock types contains abundant interbeds of the other rock type, as well as a few layers of calc-silicate rock. Much of the graywacke is graded, but some beds have a pseudolamination which is actually pressure-solution cleavage. Contains large mappable blocks of serpentinite and associated chlorite- tremolite-epidote schist, talc-chlorite schist, and talc-chlorite-actinolite schist (€Zu). The unit's thickness is not known, as its base is marked by the Plummers Island thrust fault (Drake, 1985a). It is overlain on the west by Triassic rocks

Sykesville Formation (Early Cambrian and (or) Late Proterozoic) (Hopson, 1964; Drake, 1985a)—Light- to medium-gray, medium-grained sedimentary melange consisting of a quartzofeldspathic matrix that contains fragments of foliated felsic and mafic metavolcanic rocks, quartz, metagabbro, Peters Creek Schist, and ultramafic rocks. Shown in cross section only

EXPLANATION OF MAP SYMBOLS

Contact—Dotted where concealed. Distribution and concentration of structural symbols indicates degree of reliability

Faults—dotted where concealed

U/D High angle—U, upthrown side; D, downthrown side, where known

Thrust—Sawteeth on upper plate

Overturned thrust—Sawteeth in direction of dip; bar on tectonically higher plate

FOLDS

(Dotted where concealed)

Fold phases are designated from oldest to youngest, CH, Captain Hickory; P, Potomac; R, Reston; C, Clifton; A, Accotink Creek

Anticline—Showing crest line and direction of plunge

Overturned anticline—Showing trace of axial surface, direction of dip of limbs, and direction of plunge

Antiform—Showing crest line and direction of plunge where known

Overturned antiform—Showing trace of axial surface, direction of dip of limbs, and direction of plunge

Syncline—Showing trough line and direction of plunge

Overturned syncline—Showing trace of axial surface, direction of dip of limbs, and direction of plunge

Synform—Showing trough line and direction of plunge

Overturned synform—Showing trace of axial surface, direction of dip of limbs, and direction of plunge

Overturned fold, direction of closure unknown—Showing trace of axial surface and direction of dip of limbs.

MINOR FOLDS

Minor asymmetric fold—Showing bearing and plunge of axis and rotation sense viewed down plunge

Minor anticline—Showing bearing and plunge of axis

PLANAR FEATURES

(May be combined with linear features)

Strike and dip of beds— Ball indicates top known from sedimentary structures
- Inclined
- Overturned
- Vertical

Strike and dip of foliation—Rocks of the Piney Branch Complex and Yorkshire Formation, and schistosity of indeterminate generation in other rocks
- Inclined
- Vertical

Strike and dip of phyllonitic foliation
- Inclined
- Vertical

Strike and dip of transposition foliation
- Inclined
- Vertical

Strike and dip of schistosity
- Inclined
- Vertical

Strike and dip of spaced schistosity
- Inclined
- Vertical

Strike and dip of crenulation cleavage or schistosity
- Inclined

Strike and dip of joints
- Inclined
- Vertical

LINEAR FEATURES

(May be combined with planar features)

Bearing and plunge of mineral lineations

Bearing and plunge of intersections of bedding and schistosity

Bearing and plunge of microfolds in schistosity

Bearing and plunge of intersection of crenulation cleavage and schistosity

OTHER FEATURES

⚒ Quarry

INTRODUCTION

The Vienna 7.5-minute quadrangle is largely in north-central Fairfax County, Virginia but the extreme northeast corner is in Montgomery County, Maryland. Much of the quadrangle is urban, and development is proceeding rapidly throughout the area. Piedmont crystalline rocks of the central Appalachian Internides underlie most of the quadrangle. Mesozoic sedimentary and intrusive igneous rocks crop out in the northwestern part of the quadrangle. Alluvium occurs along most streams and gravel terrace deposits occur along the Potomac River. Natural outcrops, many of which are saprolite, are largely restricted to stream valleys. Drake's knowledge of the northern Virginia crystalline rocks has been gained by abundant work in recent years (Drake, 1985a, 1985b, 1985c; 1986a, 1986b, 1986c; 1987; Drake and Froelich, 1986; Drake and Lyttle, 1981; Drake and Morgan, 1981, 1983; and Drake and others, 1979). Knowledge of the Mesozoic rocks was gained by the work of Drake and others (1979) and particularly by Lee and Froelich (1989). This work is briefly summarized below.

CRYSTALLINE ROCKS

Metamorphosed sedimentary rocks constitute most of the crystalline terrane in the Vienna quadrangle, but some volcanic and intrusive rocks are also present. Transported intrusive rocks are also fairly abundant. These rocks have been intruded by small bodies of Bear Island Granodiorite (Cloos and Cooke, 1953), quartz bodies, and one lamprophyre dike.

METASEDIMENTARY AND METAVOLCANIC ROCKS

The metasedimentary and metavolcanic rocks in this part of northern Virginia constitute a stack of four lithotectonic units (Drake and Lyttle, 1981; Drake and Morgan, 1981; Drake, 1985c, 1987). The youngest and highest of these units, the Popes Head Formation, unconformably overlies all the other units that constitute three thrust sheet-precursory melange pairs termed tectonic motifs (Drake, 1985a, 1985c). These motifs are, from highest to lowest, the Piney Branch-Yorkshire, the Peters Creek-Sykesville, and the Annandale-Indian Run. Only the Piney Branch-Yorkshire and the Peters Creek part of the Peters Creek-Sykesville motifs crop out in the Vienna quadrangle.

POPES HEAD FORMATION

The Popes Head Formation (Drake and Lyttle, 1981) unconformably overlies all the other lithotectonic units and consists of a lower Old Mill Branch Metasiltstone Member and an upper Station Hills Phyllite Member. Both members contain interbedded felsic and mafic metatuff. These rocks are interpreted to belong to Bouma's (1962) turbidite sequence T_{de} and to Mutti and Ricci Lucchi's (1978) turbidite facies D, suggesting deposition from weak turbidity flows (Drake and Lyttle, 1981). Drake and Lyttle (1981) have suggested that the formation may have resulted from the bilateral filling of a back-arc basin. Rocks of the Popes Head Formation contain the typical mineral assemblage of quartz-muscovite-biotite-plagioclase-chlorite, and the unit is at the biotite grade of metamorphism.

PINEY BRANCH—YORKSHIRE MOTIF

The Piney Branch Complex has been interpreted to be a fragment of a large dismembered ophiolite (Drake and Morgan, 1981). This complex lacks discernible order and is thought to be a tectonic melange resulting from the autoclastic deformation of a layered complex that contained repetitive cycles of ultramafic and mafic layers (Drake and Morgan, 1981). Mineralogic and chemical data for these rocks are presented in Drake and Morgan (1981). The ultramafic and mafic rocks within the complex have been retrogressively metamorphosed to mineral assemblages stable in the greenschist facies, and almost no original minerals survive. These ultramafic and mafic rocks are intruded by small dikes and sheets of leucocratic rocks having a color index of less than 2. They are composed of quartz and plagioclase and have Na_2O-K_2O ratios of more than 4 to 1. The petrographic and chemical data indicate that these rocks are similar to the metamorphosed plagiogranites of the Baltimore Complex of Maryland (Morgan, 1977) and to plagiogranites in other ophiolite complexes (Coleman and Peterman, 1975).

The Yorkshire Formation, a sedimentary melange, forms a thin discontinuous lower border to the Piney Branch Complex. It is interpreted to be a precursory melange to the Piney Branch Complex (Drake and Morgan, 1981). The Yorkshire contains mineral assemblages stable in the greenschist facies of regional metamorphism.

The Yorkshire and the overlying Piney Branch Complex constitute the highest tectonic motif in northern Virginia. The main mass of the motif extends from the southeastern part of the Vienna quadrangle to Bull Run in the Manassas 7.5-minute quadrangle (Drake and others, 1979). Two smaller masses occur a short distance to the northeast, and two even smaller masses crop out farther to the northeast in Vienna City. The motif is thought to have had a multiple movement history which involved the [illegible] emplacement of the Piney Branch upon the Yorkshire and the later thrusting of this assemblage onto the Peters Creek Schist (Drake and Morgan, 1981). The discontinuous nature of the Yorkshire is thought to reflect partial shearing out during the late thrust event. The Piney Branch-Yorkshire motif overlies the Peters Creek-Sykesville motif on the Oakton thrust fault.

PETERS CREEK—SYKESVILLE MOTIF

The Peters Creek Schist (Drake and Morgan, 1981) consists of quartz-rich schist and graywacke interpreted to be a turbidite deposited under fairly high energy conditions in a large submarine fan (Drake and Morgan, 1981). In northern Virginia and adjacent Maryland, the Peters Creek characteristically contains large blocks of ultramafic rocks (Drake and others, 1979; Froelich, 1975). In northern Virginia contact relations suggest that the ultramafic rocks are olistoliths, as do some exposures in Montgomery County, Maryland (Drake and Morgan, 1983). Ultramafic bodies are characteristic of the Peters Creek Schist as far to the northeast as the Philadelphia area, as well as probable correlative rocks southwest of the Culpeper basin (Drake and others, in press; Rankin and others, in press). It is impossible at this time to evaluate how many of these bodies are olistoliths and how many may result from tectonic emplacement. These bodies have folds not present in the surrounding schists, so they were deformed prior to emplacement. In any case, the Peters Creek Schist is a type of ophiolitic melange that was probably deposited on or adjacent to oceanic crust. The Peters Creek constitutes a major part of the Potomac terrane in the central Appalachians (Drake, 1985b).

The Peters Creek Schist is polymetamorphic. It has undergone a prograde event that ranges from chlorite grade in the west to sillimanite grade in the east (Fisher, 1963, 1970; Drake and others, 1979; Drake and Morgan, 1981; Drake, 1985b, 1986a, 1986c). About coincident with the appearance, in both time and space, of sillimanite, the rocks become migmatitic. Near Sherwin Island in the Potomac River, about 1.5 km (0.9 miles) east of the Vienna quadrangle (Drake and others, 1979, Drake and Morgan, 1981), the highest-grade rocks and migmatites become severely sheared and are retrogressively metamorphosed to chlorite-sericite phyllonites. A later metamorphic event is recognized in these rocks in which chloritoid has grown within shimmer aggregate pseudomorphs of staurolite, andalusite, and garnet.

The Peters Creek Schist overlies the Sykesville Formation, the precursory melange of the Peters Creek-Sykesville motif on the Plummers Island thrust fault (Drake, 1985a, 1986a). The Sykesville does not crop out in the Vienna quadrangle, and the reader is referred to Drake (1985a), Drake and Lyttle (1981), and Drake and Morgan (1981) for a description of that unit and its relation to the Peters Creek Schist.

PRE-MESOZOIC INTRUSIVE ROCKS

The metasedimentary and metavolcanic rocks in the Vienna quadrangle contain sills of amphibolite, small bodies of Bear Island Granodiorite, one lamprophyre dike, and a few quartz bodies.

AMPHIBOLITE

Sills of epidote-plagioclase-hornblende amphibolite intrude the Peters Creek Schist. Some specimens contain relict clinopyroxene and have diabase textures. These sills are almost certainly metadiabase. Although foliated, only the smaller sills and the margins of the larger sills are schistose. We have only recently become aware of unpublished radiometric determinations on zircon from amphibolite on the southeastern tip of Bear Island in the Falls Church quadrangle (Fisher, 1971). These determinations gave a Pb^{207}-Pb^{206} age of 525±60 Ma, and a concordia age of 550 Ma, assuming continuous diffusion. Although there is a large error bar, these dates are consistent with the regional geology and the amphibolite is considered to be of Early Cambrian age. The sills appear to be restricted to rocks of the staurolite + andalusite or higher grade zones, suggesting that they were emplaced during metamorphism.

QUARTZ BODIES

Lenticular to irregularly shaped bodies of quartz occur within both the Peters Creek Schist and Popes Head Formation. It is impossible to date these bodies, but they are interpreted to result from metamorphic differentiation within the regime of greenschist-facies metamorphism. The bodies within the Peters Creek Schist probably formed during both the early prograde and retrograde events. The body within the Popes Head Formation is interpreted to date from the prograde metamorphic event experienced by that unit.

BEAR ISLAND GRANODIORITE

Leucocratic granitoid rock forms dikes, sheets, and small irregularly shaped intrusive bodies within the high-grade part of the Peters Creek Schist from Bear Island in the Potomac River south to the overlap of Mesozoic rocks in the Manassas quadrangle (Drake and others, 1979). Similar rocks have been recognized at least as far northeast as the Patuxent River in the Woodbine 7.5-minute quadrangle in Maryland (A.A. Drake, Jr., unpub. data). The composition of these rocks varies, and they have been termed granodiorite, leucotonalite, adamellite, quartz diorite, and quartz monzonite. Cloos and Cook (1953) formally named these intrusive rocks the Bear Island Granodiorite. Hopson (1964) called the suite Bear Island Granite because of its silicic composition and because its plagioclase is albite; Drake (1986a, 1987) followed Hopson's usage. Modal data (fig. 1) are equally divided between the monzogranite, granodiorite, and tonalite fields. Most of the monzogranites, however, plot near the granodiorite field and petrographically, granodiorite appears to be the best name for these rocks. Chemically (table 1), however, most of the rocks are trondhjemite (fig. 2), and closely resemble the oceanic trondhjemites of Fiji (Gill and Stork, 1979). In any case, granodiorite appears to be the most useful rock name, although the Bear Island rocks contain more Na_2O and much less K_2O and MgO than typical granodiorites (Nockolds, 1954). More work needs to be done on these interesting rocks, but such a study will be hindered by the difficulty of finding suitable material away from the Potomac River. The name Bear Island Granodiorite is herein accepted for use by the U.S. Geological Survey.

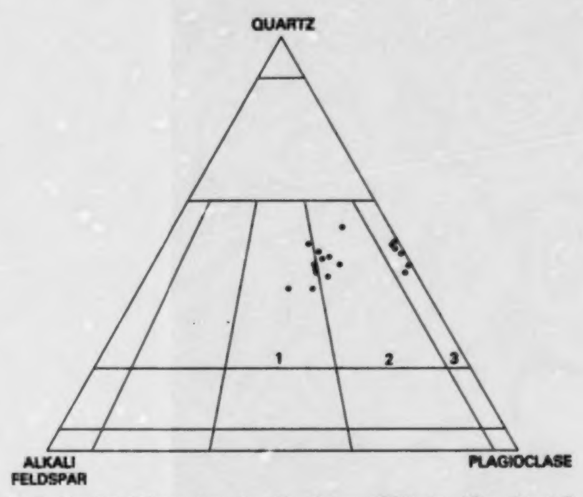


Figure 1.—Quartz-alkali feldspar-plagioclase (Streckeisen, 1976) plot of Bear Island Granodiorite. Represented fields are: 1, monzogranite; 2, granodiorite; and 3, tonalite.

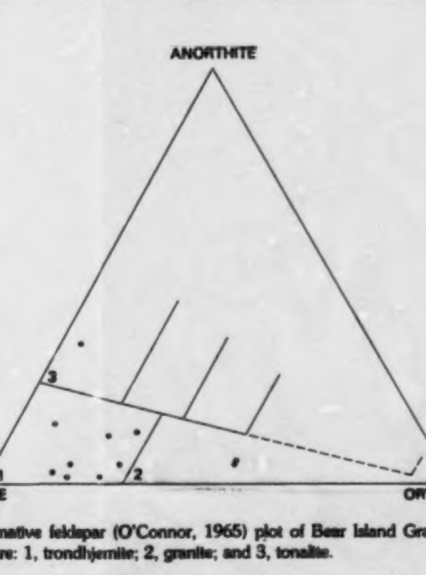


Figure 2.—Normative feldspar (O'Connor, 1965) plot of Bear Island Granodiorite. Represented fields are: 1, trondhjemite; 2, granite; and 3, tonalite.

The Bear Island Granodiorite clearly crosscuts the structures in the Peters Creek Schist, including the migmatitic layering, and is itself undeformed. Many bodies of Bear Island Granodiorite locally coarsen into pegmatite, and muscovite from two such pegmatite bodies has been dated by Rb-Sr techniques at 469±20 Ma (Muth and others, 1979). We prefer to interpret these data to represent the cooling of, not the intrusion of, the Bear Island Granodiorite. In any case, the granodiorite was emplaced after the deformation and metamorphism of the Peters Creek Schist.

LAMPROPHYRE

A lamprophyre dike crops out in the Peters Creek Schist in the northeastern part of the quadrangle. It is on the south end of Olmstead Island and is slightly offset along strike to the west across the main channel of the Potomac River. The rock is dark greenish gray, fine grained, and contains conspicuous biotite phenocrysts. According to Reed and others (1970), the dike matrix contains finely crystalline quartz, albite, calcite, biotite, epidote, sphene, and apatite. This dike, as well as others in the general area, were classed as minettes by Fisher (1963), but Reed and others (1970) point out that their lack of potassium feldspar suggests that they probably could be better termed kersantites. Two samples of biotite from the dike were dated at 363±13 Ma and 360±13 Ma by conventional K-Ar techniques, suggesting a Late Devonian age. The dike clearly post-dates the metamorphism and deformation of the Peters Creek Schist.

MESOZOIC ROCKS

Mesozoic rocks of the Culpeper basin in the Vienna quadrangle include the Reston and Poolesville Members of the Manassas Sandstone of the Culpeper Group (Lee and Froelich, 1989) of the Newark Supergroup (Froelich and Olson, 1984). These sedimentary rocks are intruded and thermally metamorphosed by diabase.

MANASSAS SANDSTONE

The Reston Member of the Manassas Sandstone unconformably overlies or is in fault contact with rocks of the Peters Creek Schist. It grades upward and laterally into the Poolesville Member. Locally, these members interfinger. Rocks of the Reston Member are interpreted to have been deposited by high-gradient streams and debris flows along the base of an eastern highland (Lee and Froelich, 1989). These rocks are probably the remnants of coalescing fans and represent lithofacies deposited in the fanhead to midfan (Lee and Froelich, 1989). Sedimentary evidence suggests that the rocks had eastern and southeastern source areas.

The Poolesville Member is the uppermost stratigraphic unit in the Manassas Sandstone. Plant fossils and spores collected from the Poolesville suggest that it might range from late Carnian to middle Norian in age (Lee and Froelich, 1989). Rocks of the Poolesville are interpreted to have been deposited by braided streams from eastern to southeastern source areas (Lee and Froelich, 1989). Thick beds of sand within the unit appears to have been deposited in areas of midfan and fan base (Lee and Froelich, 1989).

DIABASE

The Vienna quadrangle contains the eastern part of the Herndon diabase sheet, which has an average thickness of about 200 m (656 ft), as well as the southernmost dike of the north-northeast-trending Seneca system (Froelich and Gottfried, in press). Chemically, the diabase is a high (1.0–1.2 percent) TiO_2, quartz-normative (51–53 percent SiO_2) tholeiite of the York Haven type, and belongs to the east-central lineage of Froelich and Gottfried (in press). Diabase within the Culpeper basin is considered to have a mean age of 198.4±2.1 Ma based on ^{40}Ar-^{39}Ar determinations on several whole-rock samples (Sutter, 1985).

AGES OF THE METASEDIMENTARY, METAVOLCANIC, AND METAINTRUSIVE ROCKS

The ages of the metasedimentary, metavolcanic, and metaintrusive rocks cannot be directly determined, and depend on the age of the Occoquan Granite, which crops out in the adjacent Fairfax and Annandale 7.5-minute quadrangles (Drake, 1986a; Drake and Froelich, 1986). The Occoquan is Cambrian in age (Seiders and others, 1975; Mose and Nagel, 1982), and intrudes the Popes Head Formation (Drake, 1986a, 1987; Drake and Froelich, 1986; Drake and Lyttle, 1981). The Popes Head Formation unconformably overlies the Peters Creek Schist, the Yorkshire Formation, and the Piney Branch Complex; all these rocks thus are Cambrian or older. The Popes Head Formation is thought to be Cambrian in age (Drake, 1986a, 1987; Drake and Froelich, 1986). The Peters Creek Schist, Yorkshire Formation, and Piney Branch Complex have had much more complicated structural and metamorphic histories, suggesting that they may be older and possible Late Proterozoic in age. This, however, cannot be proved, and these rocks must be considered Early Cambrian and (or) Late Proterozoic in age.

STRUCTURAL GEOLOGY

The Popes Head Formation was deposited on the already assembled stack of Piney Branch-Yorkshire and Peters Creek-Sykesville Motifs. Subsequently, the stack of motifs and the Popes Head Formation were folded together. Fold phases in this quadrangle, following the usage of Tobisch and Fleuty (1969), have been named for geographic locations where they are well displayed or for the major fold of a particular phase (table 2). This was done because all fold phases are not necessarily everywhere present and numerical chronology could become confusing.

First phase folds in both the Peters Creek Schist and Popes Head Formation have an axial surface schistosity. These schistosities are not the same age, however, because the Popes Head Formation was not deposited until the Peters Creek Schist was folded three times and phyllonitized in its eastern area of outcrop. Other planar structures mapped in the Peters Creek Schist include transposition foliation (bedding totally transposed into Captain Hickory phase schistosity), spaced schistosity (Potomac phase), crenulation cleavage (Reston phase), and phyllonitic foliation. Phyllonitic foliation appears to be the result of the transposition of earlier planar elements into a fourth phase spaced schistosity. It was impossible at many places, particularly in saprolite, to identify planar elements within the Peters Creek Schist. A foliation symbol is shown at such places on the map.

FOLDS IN THE POPES HEAD FORMATION

The Clifton is the oldest fold phase in the Popes Head Formation. It was named for the Clifton syncline (Drake, 1986a, 1987), the northern terminus of which is in the Falls Church 7.5-minute quadrangle. The characteristics of Clifton folds are given in table 2. Two smaller synclines cored with Popes Head Formation in the southern part of the Vienna quadrangle are also Clifton folds.

The outcrop pattern of the Popes Head Formation in the Fairfax and Manassas quadrangles to the south, as well as direct observations in the field and structural-geometric analysis (Drake, 1986a, 1987), show that Clifton schistosity and folds are folded about more northerly trending axes. These folds were named Accotink Creek for the creek of that name in the northern part of the Fairfax quadrangle (Drake, 1986a, 1987). They are nearly coaxial and coplanar with Clifton folds, and at many places bedding and Clifton schistosity are transposed into a spaced schistosity that is axial planar to Accotink Creek folds (table 2). For these reasons, Accotink Creek folds are difficult to recognize in the field. This recognition is further complicated by the tendency for earlier fold axes to rotate into parallelism with later axes if the intermediate strain axis of the later deformation field is inclined less than 30° from that of the earlier intermediate strain axis (Ghosh and Ramberg, 1968). Accotink Creek folds are interpreted to have resulted from progressive deformation within a stress continuum during progressive regional dynamic metamorphism (Drake, 1987). Major Accotink Creek folds affecting the Popes Head Formation in this quadrangle are the Vienna syncline and the Cunningham Park anticline.

FOLDS IN THE PINEY BRANCH—YORKSHIRE MOTIF

In the Fairfax and Manassas quadrangles to the south, previously deformed rocks of the Piney Branch Complex and Yorkshire Formation are folded with the Popes Head Formation in the major Clifton-phase (table 2) Jermantown synform (Drake, 1986a, 1987; Drake and others, 1979). Farther north, the Popes Head unconformity cuts down onto the Peters Creek Schist. The Peters Creek is exposed below the Piney Branch-Yorkshire motif to the northern terminus of the Jermantown synform in this quadrangle. Outlying bodies of the motif core four small subsidiary Clifton-phase synforms. No later fold phases were recognized in these rocks in the Vienna quadrangle.

FOLDS IN THE PETERS CREEK SCHIST

Deformation in the Peters Creek Schist is quite complex and at most places bedding and first-generation schistosity are nearly parallel, forming the tectonic surface called "bedding schistosity" by Hopson (1964). At many places, as recognized by Fisher (1963, 1970), small fold hinges of bedding can be found tucked within the schistosity; these folds are Fisher's F_2 folds. Many of these hinges plunge down the dip of later schistosity, but others have apparently been rotated into parallelism with later folds. This relation is geometrically shown on figure 3A. Here small fold axes and the intersections of bedding and schistosity plot on a great circle girdle, indicating refolding of earlier formed lineations. Many of those lineations plunge very steeply, and very many plunge more than 40°. Heretofore mappable first folds have not been recognized in the Peters Creek Schist. The distribution of metagraywacke in low-grade rocks in the Seneca 7.5-minute quadrangle to the north (Drake and others, 1979) indicate that a major early fold there trends somewhat north of west, and that it has been contracted by later nearly north-trending folds. In the Vienna quadrangle three areas of metagraywacke define fold axes that have been severely contracted by later folding, like the more straightforward example in the Seneca quadrangle. This interpretation is supported by a limited number of basin and dome fold-interference patterns seen in outcrop. Such patterns result from the near right-angle intersection of fold systems. The five early folds are the Captain Hickory, Colvin Run, Hunter, Glade, and Legato folds, and this phase is herein named the Captain Hickory phase for the fold along Captain Hickory Run in the northeastern part of the quadrangle. These folds are isoclinal and it is not known in which direction they close. The regional schistosity, the "bedding schistosity" of Hopson (1964) and Fisher (1963, 1970), is axial surface to these folds (table 2). It is interesting to note that Fisher (1970) found that the few early folds that he could measure trended about east-west.

It is relatively easy to recognize the younger folds in areas where the Popes Head Formation crops out because the Peters Creek Schist is folded with the Popes Head in the Clifton syncline as well as other Clifton and Accotink Creek folds (Drake, 1986a, 1987). Drake (1987) has shown that the fold geometry of phyllonitic Peters Creek Schist is the same as that of the Popes Head. The Clifton syncline continues into the Vienna quadrangle and its axis is folded about the Accotink Creek-phase Vienna syncline and Cunningham Park anticline.

The folds in the Peters Creek Schist are more difficult to phase in areas away from the Popes Head Formation. Numerous folds deform the axes of the major Captain Hickory folds and the regional, first generation Captain Hickory schistosity. This is well shown on figure 3A as well as on figure 3B, which shows that the majority of the folds in the Captain Hickory schistosity plunge just west of north (or east of north) and north-northwest. These folds, which largely control the map pattern in the Potomac Valley, are herein termed Potomac folds (table 2). They were termed F_3 folds by Fisher (1963, 1970). They could be confused with both Clifton and Accotink Creek folds, but they have prograde minerals in their axial surface spaced schistosity, whereas the Clifton and Accotink Creek folds deform the retrograde phyllonitic foliation in the Peters Creek Schist. The Potomac folds are similar in form and are greatly thickened in hinge zones in both quartzose schist and metagraywacke. Interference of Potomac folds with younger Clifton and Accotink Creek folds is not apparent in outcrop because of poor exposure in critical areas. It is probable, however, that the Legato antiform was misinterpreted by Drake (1986a) in the Fairfax quadrangle and it is more likely a Potomac fold reoriented into a Clifton trend.

Drake (1987) suggested that the lenticular nature of the mapped metagraywacke intervals may result from regional transposition, as do lenticular rock bodies in other complex orogens. An intriguing possibility is that the metagraywacke-cored Potomac folds are actually dismembered and reoriented Captain Hickory folds.

The axis of the Potomac-phase Lake Anne antiform in the Reston area is folded by two northwest-trending structures. These folds have an axial surface crenulation cleavage. Several small folds of similar trend in the same general area also have a crenulation cleavage parallel to their axial surfaces. These folds are herein named Reston folds (table 2). These folds may be more common than mapped, particularly in the Seneca quadrangle to the north (A. A. Drake, Jr., unpub. data).

JOINTS IN CRYSTALLINE ROCKS

Joints are important conduits for the exploitation or disposal of fluids in a crystalline terrane. Figure 3C shows that in the Vienna quadrangle the strong joint maxima strike N. 55° W. and N. 85° W. and dip steeply southwest. There are lesser concentrations at different orientations. It is interesting to note that the N. 85° W. set is geometrically consistent to be a cross joint related to Potomac phase folding, and the N. 55° W. set is cross joint related to either Clifton- or Accotink Creek-phase folding in the southeastern part of the quadrangle.

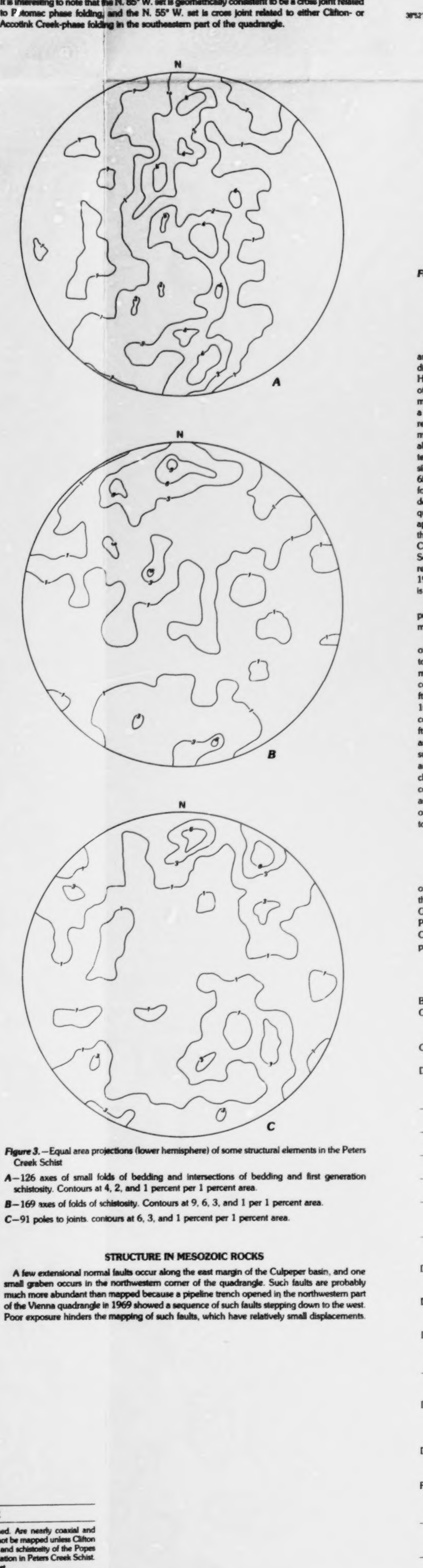


Figure 3.—Equal area projections (lower hemisphere) of some structural elements in the Peters Creek Schist.

A—126 axes of small folds of bedding and intersections of bedding and first generation schistosity. Contours at 4, 2, and 1 percent per 1 percent area.

B—169 axes of folds of schistosity. Contours at 9, 6, 3, and 1 per 1 percent area.

C—91 poles to joints. Contours at 6, 3, and 1 percent per 1 percent area.

STRUCTURE IN MESOZOIC ROCKS

A few extensional normal faults occur along the east margin of the Culpeper basin; and one small graben occurs in the northwestern corner of the quadrangle. Such faults are probably much more abundant than mapped because a pipeline trench opened in the northwestern part of the Vienna quadrangle in 1969 showed a sequence of such faults stepping down to the west. Poor exposure hinders the mapping of such faults, which have relatively small displacements.

Table 1.—Chemical analyses and C.I.P.W. norms of the Bear Island Granodiorite (weight percent)

Sample No.	1	2	3	4	5	6	7	8	9	10	11
SiO_2	74.9	76.6	75.5	76.2	74.0	58.1	68.4	77.2	75.4	74.0	77.01
Al_2O_3	14.2	14.3	14.7	13.5	13.8	25.5	18.5	13.3	13.8	14.5	13.47
Fe_2O_3	1.9	0.51	0.32	0.8	0.32	0.13	0.65	0.13	0.29	0.73	0.48
FeO	0.16	0.20	0.40	0.36	0.24	0.88	0.32	0.7	0.24	0.20	1.15
MgO	0.17	0.20	0.18	0.37	0.29	0.36	0.42	0.29	0.19	0.15	0.15
CaO	1.3	0.31	0.81	1.2	0.95	6.5	2.4	0.22	0.62	0.66	0.53
Na_2O	3.9	5.1	5.1	3.4	3.1	6.7	6.6	4.4	3.1	6.1	3.69
K_2O	1.9	1.5	1.6	2.2	5.5	0.7	0.88	2.0	5.2	1.4	2.18
H_2O+	0.65	0.6	0.88	0.76	0.14	0.72	0.62	0.74	0.59	0.52	0.89
H_2O-	0.09	0.11	0.11	0.12	0.86	0.1	0.14	–	–	0.21	0.01
TiO_2	0.04	0.08	0.08	0.19	0.11	0.17	0.19	0.09	0.07	0.04	0.10
P_2O_5	0.21	0.08	0.2	–	0.11	0.11	0.11	0.14	0.1	0.12	0.06
MnO	0.06	0.08	0.04	0.08	0.10	0.1	0.07	0.06	0.03	0.04	0.13
CO_2	.41	0.05	0.05	0.26	0.08	0.08	0.05	0.05	0.05	0.04	0.13
Total	99.89	99.72	99.97	99.44	99.60	100.15	99.35	99.32	98.68	98.71	99.98
C.I.P.W. Norms (weight percent)											
Quartz	42.7	41.7	38.2	46.6	32.6	1.4	21.5	43.3	36.5	32.6	45.8
Orthoclase	11.1	8.9	9.4	12.8	33.4	3.9	5.6	11.7	30.6	8.3	12.8
Albite	34.1	43.0	44.0	29.3	27.2	57.6	56.6	38.2	26.2	52.4	31.4
Anorthite	5.6	0.6	3.1	5.8	3.9	32.0	11.1	0.8	3.3	2.5	2.5
Corundum	3.7	4.2	3.5	3.5	1.1	2.0	2.6	3.6	1.9	2.1	4.2
Diopside	0.4	0.5	0.8	1.0	0.8	2.3	1.1	1.9	0.5	0.4	2.2
Wollastonite	–	–	–	–	–	–	–	–	–	–	–
Hypersthene	–	–	–	–	–	–	–	–	–	–	–
Magnetite	0.7	0.7	0.5	0.7	0.5	0.2	0.5	0.2	0.5	0.7	0.7
Apatite	0.3	0.3	0.3	–	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Ilmenite	–	0.2	0.2	0.5	0.2	0.3	0.5	0.2	0.2	0.3	0.2
Titanite	–	–	–	–	–	–	–	–	–	–	–
Hematite	1.4	–	–	0.3	–	–	0.3	–	–	0.2	–
Total	100.0	100.1	100.0	100.5	100.0	100.0	100.1	100.2	100.0	99.8	100.1

Rapid rock analyses by P. Elmore, S. Botts, H. Smith, G. Chloe, J. Kelsey, J. Glenn, and L. Artis, USGS, Samples 1–7; P. Elmore, I.H. Barlow, S. Botts, and G. Chloe, USGS, Samples 8-9; and K. Coates and H. Smith, USGS, (Sample 10). Sample 11 from Hopson (1964).

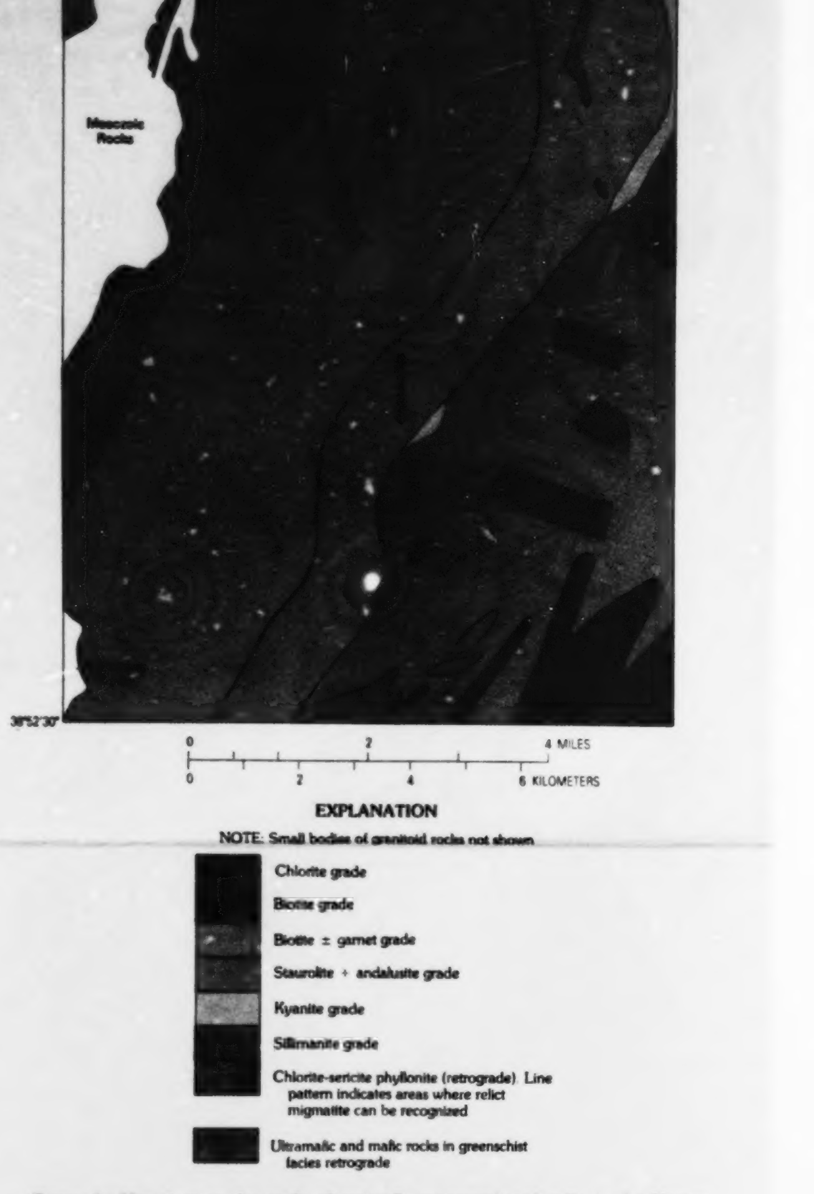
Description of samples

All samples from the Falls Church 7.5-minute quadrangle except when noted

1. Light-colored granodiorite dike cutting migmatitic schist. Southern part of Bear Island
2. Light-colored granodiorite dike cutting calc-silicate gneiss. Southern part of Bear Island
3. Light-colored granodiorite dike cutting calc-silicate gneiss. Southern part of Bear Island
4. Light-colored granodiorite cutting migmatitic schist. Northern part of Bear Island
5. Monzogranite stock cutting migmatitic schist. Northern part of Bear Island
6. Diorite dike cutting amphibolite. Northern part of Bear Island
7. Tonalite dike cutting amphibolite. Southern part of Bear Island
8. Granodiorite sheet cutting schist. Sherwin Island.
9. Large monzogranite stock cutting migmatitic schist and amphibolite. Northern part of Bear Island
10. Light-colored granodiorite sheet cutting schist. Cut along Southern Railroad about 363 m (1,200 ft) southwest from trestle across Bull Run, Manassas 7.5-minute quadrangle, Va.
11. Biotite-muscovite granodiorite. Western end of Bear Island (Hopson, 1964)

Table 2.—Fold phases in the Vienna 7.5-minute quadrangle

PHASE	TREND	FOLIATION	LINEATION	STYLE
Accotink Creek	North-northeast	Spaced schistosity	Intersections with earlier schistosity	Tight, upright to isoclinal overturned. Are nearly coaxial and coplanar with Clifton folds and cannot be mapped unless Clifton folds are recognized. Fold bedding and schistosity of the Popes Head Formation and phyllonitic foliation in Peters Creek Schist. Plunge either northeast or southwest
Clifton	Northeast	Phyllitic schistosity in Popes Head Formation	Intersection with bedding in Popes Head Formation	Isoclinal overturned to tight upright. Have long planar limbs and most have interlimb angles of less than 50°. Fold bedding in Popes Head Formation and schistosity and phyllonitic foliation in the Peters Creek Schist
Reston	Northwest	Crenulation cleavage	Intersection with Captain Hickory schistosity and Potomac spaced schistosity	Tight isoclinal. Only two folds large enough to map in this quadrangle. Many mesoscopic folds
Potomac	North-northeast to north-northwest	Spaced schistosity, contains prograde minerals	Intersection with Captain Hickory schistosity	Tight to isoclinal, upright to overturned, similar folds. Fold both bedding and Captain Hickory schistosity. Control the map pattern in all but the southeastern part of the quadrangle
Captain Hickory	Apparently west or slightly north of west	Regional schistosity in Peters Creek Schist	Mineral lineation in higher-grade rocks and intersections of schistosity with bedding in Peters Creek Schist	Isoclinal, bedding nearly parallel to schistosity in most exposures. Small folds, intersection lineations and mineral lineations plunge down the dip of later foliations unless they have been rotated into parallelism with later fold axes



EXPLANATION

NOTE: Small bodies of granitoid rocks not shown

- Chlorite grade
- Biotite grade
- Biotite ± garnet grade
- Staurolite + andalusite grade
- Kyanite grade
- Sillimanite grade
- Chlorite-sericite phyllonite (retrograde). Line pattern indicates areas where relict migmatite can be recognized
- Ultramafic and mafic rocks in greenschist facies retrograde

Figure 4.—Map showing the grade of regionally metamorphosed rocks in the Vienna quadrangle.

METAMORPHISM

The pre-Mesozoic rocks within the Vienna quadrangle have been regionally metamorphosed, and where adjacent to the Herndon diabase sheet, thermally metamorphosed. Rocks of the different lithotectonic units have had different metamorphic histories (fig. 4). Rocks of the Popes Head Formation are at biotite grade and have undergone only one metamorphic event. Rocks of the Peters Creek Schist have had a much more complex metamorphic history. As was mentioned above, these rocks have undergone a major prograde event, a retrograde event, and a second prograde event. In this quadrangle, all the zones of the first prograde event can be recognized (fig. 4). The occurrence of andalusite, kyanite, and sillimanite suggest that this metamorphism was accomplished near the aluminum silicate triple point, that is at a pressure of about 3.8 kilobars (Holdaway, 1971). The highest-grade rocks are migmatitic, suggesting temperatures near the H_2O-saturated granite minimum; some specimens contain coexisting sillimanite and microcline. The maximum temperature of metamorphism was probably about 650°C, the temperature at which the second sillimanite isograd intersects the granite minimum for XH_2O=.5–1.0 (Kerrick, 1982). The chlorite-sericite retrograde zone as mapped largely destroys the kyanite- and sillimanite-zone mineral assemblages in the southern two-thirds of the quadrangle. At places, migmatite can be recognized by the presence of sheared leucosome. It appears, but is not certain, that the growth of new minerals within the phyllonite resulted from the metamorphism in the rocks of the Popes Head Formation. Rocks within the Piney Branch Complex and the Yorkshire Formation, as well as the ultramafic rocks within the Peters Creek Schist, have been metamorphosed to mineral assemblages stable in the greenschist facies of regional metamorphism and almost no relict original minerals survive (Drake and Morgan, 1981). It is impossible at this time to relate this metamorphism to that in the other rocks, but it is a distinct possibility.

Thermally metamorphosed rocks are not shown on figure 4 because the paucity of exposure prevented the mapping of the metamorphic zones. The thermal aureole, however, was mapped.

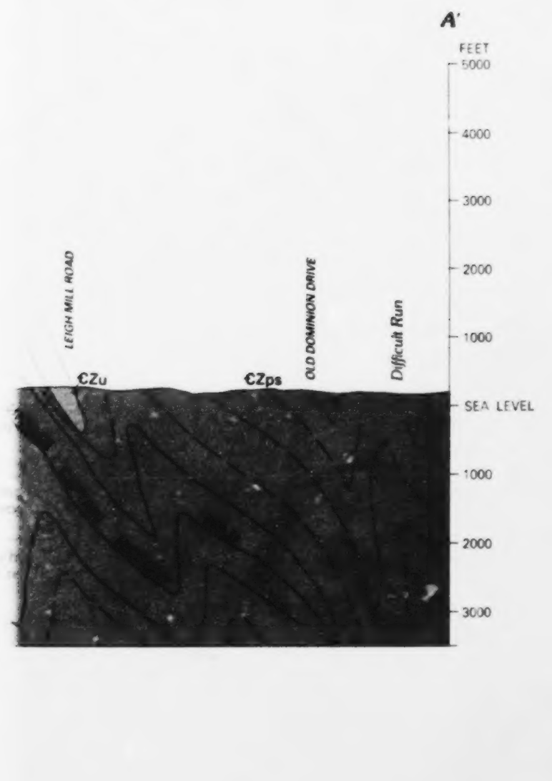
Beneath the Herndon diabase sheet, the more argillaceous rocks of the Poolesville Member of the Manassas Sandstone, as well as the Peters Creek Schist, are thermally metamorphosed to hornfels, whereas the sandy and conglomeratic rocks are altered to granofels. Within the metamorphic aureole, hornfels has an inner zone 2 to 5 m (6.5 to 16.5 ft) thick, containing cordierite, biotite, quartz, and plagioclase, succeeded by a middle zone 15 to 100 m (49 to 328 ft) thick containing cordierite, andalusite, plagioclase, and quartz, and finally by an outer zone 10 to 30 m (33 to 98.5 ft) thick containing chlorite, epidote, and quartz (Lee, 1982). Granofels consists of fused lenses, layers, and irregular masses. The inner metamorphic zone is 10 m (33 ft) thick and these rocks contain decussate biotite, plagioclase, and recrystallized quartz or an assemblage of hornblende, sodic plagioclase, titanite, and myrmekite-quartz. This zone is succeeded outward by a middle zone 16 m (52.5 ft) thick containing the assemblage cordierite, andalusite, plagioclase, and recrystallized quartz, or the assemblage black tourmaline, plagioclase, and quartz. This is surrounded by an outer zone 10 to 30 m (33 to 98.5 ft) thick, containing chlorite and epidote. These mineral assemblages suggest that the rocks in the inner and middle zones within the aureole are in hornblende-hornfels facies and that the rocks in the outer zone are in albite-epidote-hornfels facies. Temperatures apparently were not high enough to metamorphose these rocks in pyroxene-hornfels facies.

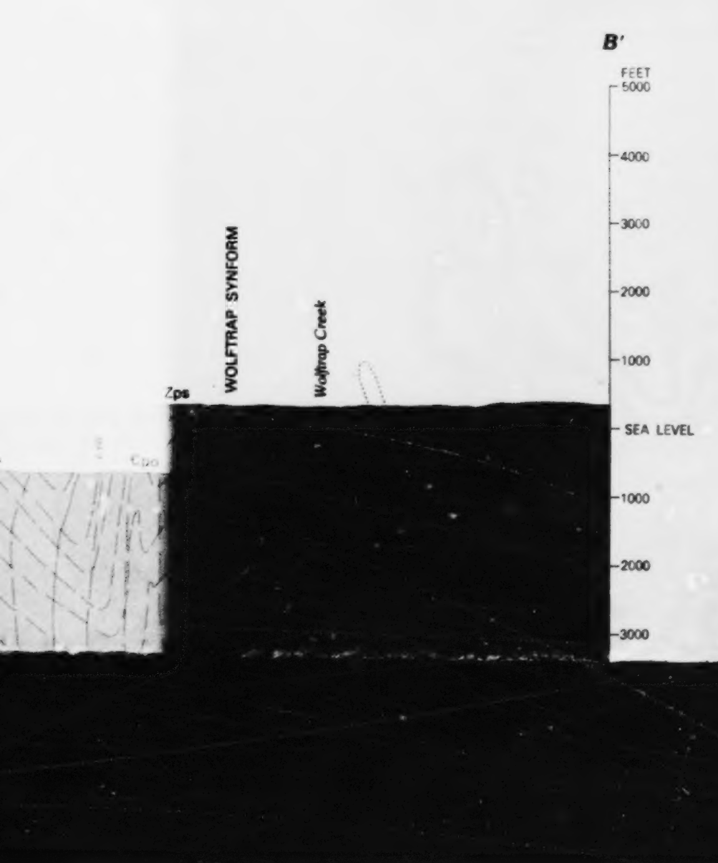
TIME OF DEFORMATION

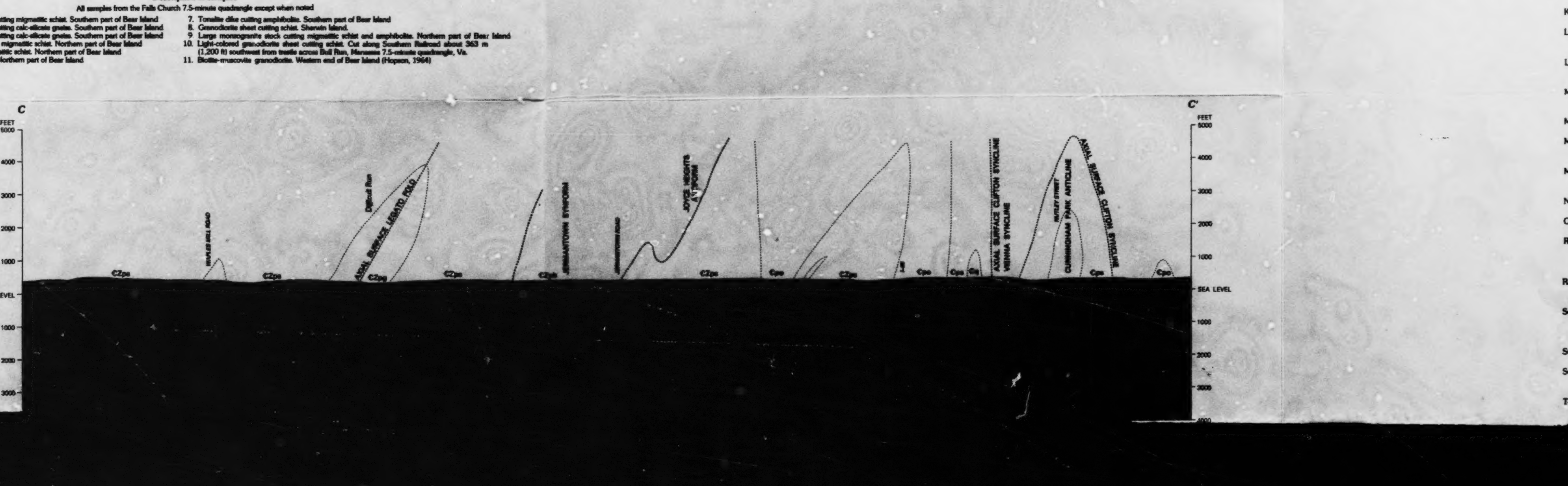
The pre-Mesozoic deformation in the Vienna quadrangle is thought to predate the Taconic orogeny because this deformation is either synchronous with or predates the emplacement of the Occoquan batholith in Cambrian (probably Upper Cambrian) time (Drake, 1987). The Occoquan was emplaced synkinematically during Clifton folding. This deformation then was a Penobscottian or earlier event (Drake, 1987). Rocks of the Piney Branch-Yorkshire and Peters Creek-Sykesville motifs have experienced a much more complex geologic history and their pre-Clifton structures may date from the Cadomian orogeny.

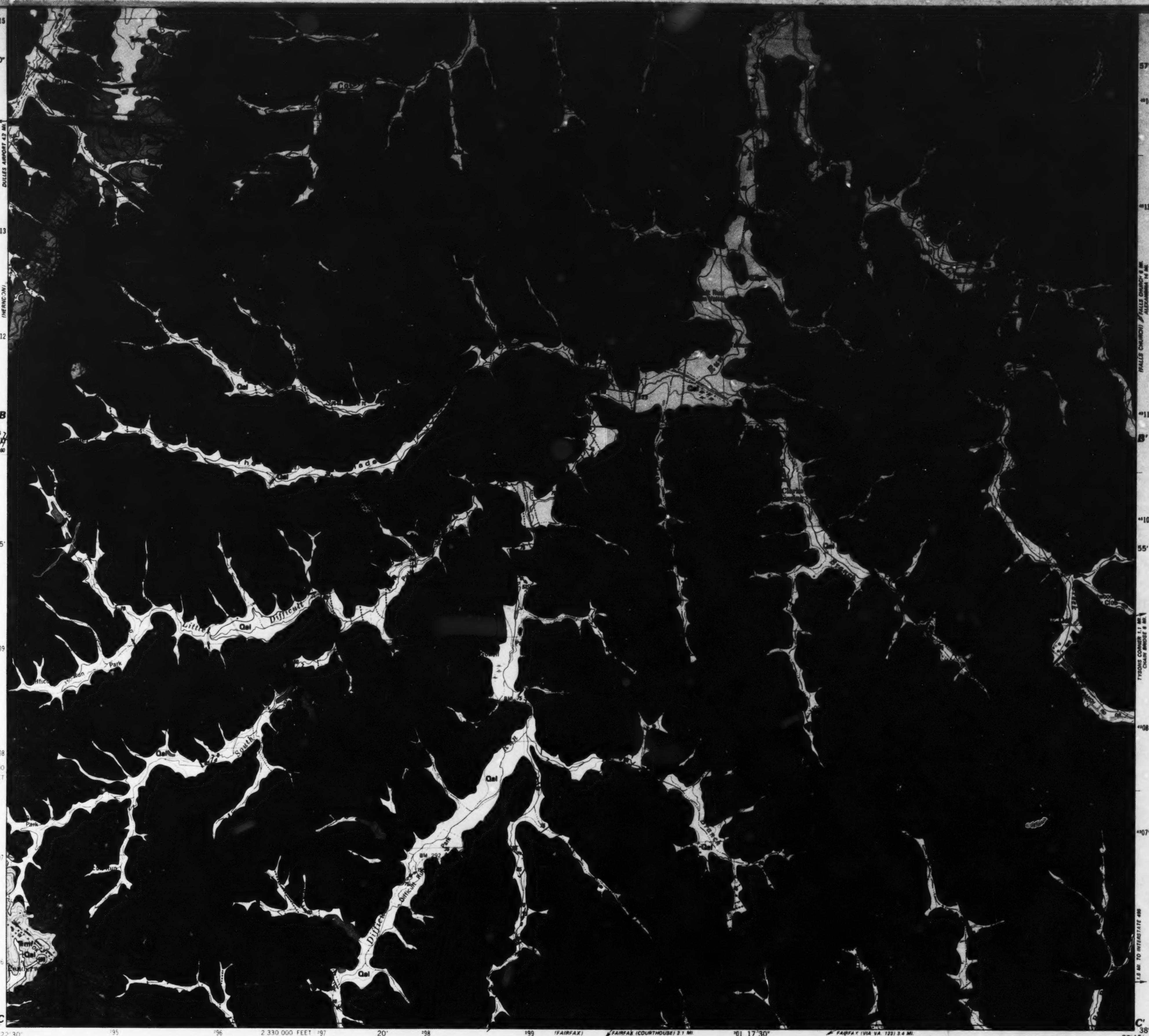
REFERENCES CITED

Bouma, A.H., 1962, Sedimentology of some flysch deposits: Amsterdam, Elsevier, 168 p.
Cloos, Ernst, and Cooke, C.W. 1953, Geologic map of Montgomery County and the District of Columbia: Maryland Department of Geology, Mines, and Water Resources, scale 1:62,500.
Coleman, R.G., and Peterman, Z.E., 1975, Oceanic plagiogranite: Journal of Geophysical Research, v. 80, no. 8, p. 1099–1108.
Drake, A.A., Jr., 1985a, Tectonic implications of the Indian Run Formation—a newly recognized sedimentary melange in the northern Virginia Piedmont: U.S. Geological Survey Professional Paper 1324, 12 p.
_____ 1985b, Metamorphism in the Potomac composite terrane, Virginia-Maryland: Geological Society of America Abstracts with Programs, v. 17, no. 7, p. 566.
_____ 1985c, Sedimentary melanges of the central Appalachian Piedmont: Geological Society of America Abstracts with Programs, v. 17, no. 7, p. 566.
_____ 1986a, Geologic map of the Fairfax quadrangle, Fairfax County, Virginia: U.S. Geological Survey Geologic Quadrangle Map GQ-1600, scale 1:24,000.
_____ 1986b, Probable Late Proterozoic rocks of the central Appalachian Piedmont: Geological Society of America Abstracts with Programs, v. 18, no. 1, p. 14.
_____ 1986c, Field Trip to Potomac Gorge, in Cargill, S.M., and Green, S.B., eds., Prospects for mineral resource assessments on public lands—Proceedings of the Leesburg workshop: U.S. Geological Survey Circular 980, p. 328.
_____ 1987, Pre-Taconian deformation in the Piedmont of the Potomac Valley-Penobscotian, Cadomian, or both? in Contributions to Virginia Geology - VI (Harris Volume): Virginia Division of Mineral Resources Publication 74, 18 p.
Drake, A.A., Jr., and Froelich, A.J., 1986, Geologic map of the Annandale quadrangle, Fairfax and Arlington Counties, and Alexandria City, Virginia: U.S. Geological Survey Geologic Quadrangle Map GQ-1601, scale 1:24,000.
Drake, A.A., Jr., and Lyttle, P.T., 1981, The Accotink Schist, Lake Barcroft Metasandstone, and Popes Head Formation—keys to an understanding of the tectonic evolution of the northern Virginia Piedmont: U.S. Geological Survey Professional Paper 1205, 16 p.
Drake, A.A., Jr., and Morgan, B.A., 1981, The Piney Branch Complex—a metamorphosed fragment of the central Appalachian ophiolite in northern Virginia: American Journal of Science, v. 281, p. 484–508.
_____ 1983, Reply: Melanges and the Piney Branch Complex—a metamorphosed fragment of the central Appalachian ophiolite in northern Virginia: American Journal of Science, v. 283, no. 4, p. 376–381.
Drake, A.A., Jr., Sinha, A.K., Laird, Jo, and Guy, R.E., in press, The Taconic orogen, in Hatcher, R.D., Jr., Thomas, W.A., and Viele, G.W., eds., The Appalachian-Ouachita Orogen, U.S.: Boulder, Colorado, Geological Society of America, The Geology of North America, v. F-2.
Drake, A.A., Jr., Nelson, A.E., Force, L.M., Froelich, A.J., and Lyttle, P.T., 1979, Geologic map of Fairfax County, Virginia: U.S. Geological Survey Open-File Report 79–398, scale 1:48,000.
Fisher, G.W., 1963, The petrology and structure of the crystalline rocks along the Potomac River near Washington, D.C.: Baltimore, Md., The Johns Hopkins University, Ph.D. dissertation, 241 p.
_____ 1970, The metamorphosed sedimentary rocks along the Potomac River near Washington, D.C., in Fisher, G.W., and others, eds., Studies of Appalachian geology, central and southern: New York, Interscience, p. 299–315.
_____ 1971, The Piedmont crystalline rocks at Bear Island, Potomac River, Maryland: Maryland Geological Survey Guidebook 4, 32 p.
Froelich, A.J., 1975, Bedrock map of Montgomery County, Maryland: U.S. Geological Survey Miscellaneous Investigations Series Map I-920-D, scale 1:62,500.
Froelich, A.J., and Gottfried, David, in press, An overview of early Mesozoic intrusive rocks in the Culpeper basin, Virginia and Maryland, in Froelich, A.J., and Robinson, G.R., Studies of the early Mesozoic basins of the eastern United States: U.S. Geological Survey Bulletin 1776.
Froelich, A.J., and Olsen, P.E., 1984, Newark Supergroup, a revision of the Newark Group in eastern North America, in Contributions to stratigraphy: U.S. Geological Survey Bulletin 1537-A, p. A55-A58.
Ghosh, S.K., and Ramberg, Hans, 1968, Buckling experiments on intersecting fold patterns: Tectonophysics, v. 5, p. 89–105.
Gill, J.B., and Stork, A.L., 1979, Miocene low-K dacites and trondhjemites of Fiji, in Barker, Fred, ed., Trondhjemites, dacites and related rocks: Amsterdam, Elsevier Scientific Publishing Company, p. 629–649.
Holdaway, M.J., 1971, Stability of andalusite and the aluminum silicate phase diagram: American Journal of Science, v. 271, p. 97–131.
Hopson, C.A., 1964, The crystalline rocks of Howard and Montgomery Counties, in The geology of Howard and Montgomery Counties: Baltimore, Md., Maryland Geological Survey, p. 27–215.
Kerrick, D.M., 1982, Experimental determination of muscovite + quartz stability with P_{H_2O} < P_{total}: American Journal of Science, v. 272, p. 946-958.
Lee, K.Y., 1982, Thermal metamorphism of Triassic and Jurassic sedimentary rocks in the Culpeper basin, Virginia: Geological Society of America Abstracts with Programs, v. 14, no. 1 and 2, p. 34.
Lee, K.Y., and Froelich, A.J., 1989, Triassic-Jurassic stratigraphy of the Culpeper and Barboursville basins, Virginia and Maryland: U.S. Geological Survey Professional Paper 1472, p. 12–16.
Morgan, B.A., 1977, The Baltimore Complex, Maryland, Pennsylvania, and Virginia, in Coleman, R.G. and Irwin, W.P., eds., North American Ophiolites: Oregon Department of Geology and Mineral Industries Bulletin 95, p. 41–49.
Mose, D.G., and Nagel, M.S., 1982, Plutonic events in the Piedmont of Virginia: Southeastern Geology, v. 23, no. 1, p. 25-39.
Muth, K.G., Arth, J.G., and Reed, J.C., Jr., 1979, A minimum age for the high-grade metamorphism and granite intrusion in the Piedmont of the Potomac River gorge near Washington, D.C.: Geology, v. 7, no. 7, p. 349–350.
Mutti, Emiliano, and Ricci Lucchi, F.R., 1978, Turbidites of the northern Apennines—Introduction to facies analysis: Falls Church, Va., American Geologic Institute Reprint Series 3, p. 127–166.
Nockolds, S.R., 1954, Average chemical compositions of some igneous rocks: Geological Society of America Bulletin, v. 65, p. 1007–1032.
O'Connor, J.T., 1965, A classification for quartz-rich igneous rocks based on feldspar ratios: U.S. Geological Survey Professional Paper 525B, p. B79-B84.
Rankin, D.W., Drake, A.A., Jr., and Ratcliffe, N.M., in press, Geologic map of the U.S. Appalachians showing the Laurentian margin and Taconic orogen, in Hatcher, R.D., Jr., Thomas, W.A., and Viele, G.W., eds., The Appalachian-Ouachita Orogen, U.S.: Boulder, Colorado, The Geological Society of America, The Geology of North America, v. F-2.
Reed, J.C., Jr., Marvin, R.F., and Mangum, J.H., 1970, K-Ar ages of lamprophyre dikes near Great Falls, Maryland-Virginia: U.S. Geological Survey Professional Paper 700-C, p. C145-C149.
Seiders, V.M., Mixon, R.B., Stern, T.W., Newell, M.F., and Thomas, C.B., 1975, Age of plutonism and tectonism and a new minimum age limit on the Glenarm Series in the northeast Virginia Piedmont near Occoquan: American Journal of Science, v. 275, no. 5, p. 481–511.
Streckeisen, Albert, 1976, To each plutonic rock its proper name: Earth Science Reviews, v. 12, p. 1–33.
Sutter, J.F., 1985, Progress on geochronology of Mesozoic diabase and basalts, in Proceedings of the Second U.S. Geological Survey Workshop on the early Mesozoic basins of the eastern United States: U.S. Geological Survey Circular 945, p. 110–114.
Tobisch, O.T., and Fleuty, M.J., 1969, Use of geographic names for successive fold phases in areas of multiple folding: Geological Society of America Abstracts with Programs, v. 7, pt. 7, p. 225–226.






C
C'
FEET
5000
4000
SEA LEVEL
€Zps
Difficult Run
AXIAL SURFACE CLIFTON SYNCLINE
CUNNINGHAM PARK ANTICLINE
AXIAL SURFACE CLIFTON SYNCLINE
VIENNA SYNCLINE
JERMANTOWN SYNFORM



Base from U.S. Geological Survey 1951
Photorevision as of 1982
10,000-foot grid based on Virginia coordinate system, north zone

SCALE 1:24 000
1 MILE
1 KILOMETERS
CONTOUR INTERVAL 10 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

Crystalline rocks mapped by A.A. Drake, Jr., 1974–76
Mesozoic rocks mapped by K.Y. Lee, 1974
Manuscript approved for publication May 17, 1988

DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Artificial fill—Various sandy and gravelly materials; occupies low-lying areas filled for construction of highways, bridges, and railroad beds

Alluvium (Holocene)—Sand, gravel, silt, and clay underlying sinuous flood plains along most streams; clastic sediments are in fairly well-bedded, well- to poorly sorted, graded fluvial, cyclic deposits with gravel at base of upward fining sequences; as much as 7 m (23 ft thick). Commonly micaceous silts and sands with quartz and crystalline rock pebbles, cobbles, and boulders in streams draining Piedmont terrain

Terrace deposits (Holocene (?))—Gravel, sand, silt, and clay deposits along Potomac River

MESOZOIC ROCKS

Diabase (Early Jurassic)—Medium- to dark-gray; largely equigranular, locally microcrystalline to fine-crystalline near the chilled margins, but coarse-crystalline in central parts of larger bodies. Consists of grayish-green to black crystals of augite and pigeonite and scattered granules or aggregates of magnetite and ilmenite which fill interstices between euhedral and subhedral light-gray plagioclase laths. Forms the Herndon sheet and a dike in the northwestern corner of the quadrangle

Thermally metamorphosed rocks (Late Triassic)—Gray to dark-gray, medium-bluish-gray, and olive-black hornfels and granofels which are metamorphosed sandstone of the Poolesville Member of the Manassas Sandstone. Cordierite hornfels and tourmaline granofels are the major rock types in the metamorphic aureole beneath the Herndon diabase sheet

Poolesville Member of Manassas Sandstone (Late Triassic) (Lee and Froelich, 1989)—Dusky-red to grayish-red to very dark-red, very fine- to medium-grained feldspathic, micaceous, ferruginous sandstone. Thin- to very thick-bedded and massive, and planar crossbedded. Locally it contains lenses and beds of light-gray to gray, medium- to very coarse-grained, feldspathic sandstone and quartzite pebble conglomerate. Thickness is variable but may exceed 1 km (3,281 ft) in places

Reston Member of Manassas Sandstone (Late Triassic) (Lee and Froelich, 1989)—Predominantly pebble to boulder conglomerate containing subangular clasts of schists, quartz, and quartzite in a matrix of fine- to coarse-grained arkosic sand or clayey silt. Contains some beds of micaceous, calcareous, clayey, feldspathic siltstone, fine- to medium-grained crossbedded sandstone; and pebbly, feldspathic, coarse-grained sandstone. In this quadrangle the unit ranges from 3 m (10 ft) to 30 m (98.5 ft) in thickness

PIEDMONT ROCKS

Intrusive Rocks

Lamprophyre (Late Devonian)—Fine-grained, dark-greenish-gray, biotite-quartz-plagioclase dike

Bear Island Granodiorite (Ordovician(?)) (Cloos and Cooke, 1953)—Fine-grained, very leucocratic, muscovite-biotite granodiorite and related pegmatite composed largely of quartz, albite, and microcline. Forms small- to moderate-sized sheets and crosscutting bodies. Found only within Peters Creek Schist (ЄZps and ЄZpg)

Quartz bodies (Cambrian)—Lenticular bodies or irregular masses. Some bodies are foliated or polyfoliated, whereas others are massive

Amphibolite (Lower Cambrian)—Fine- to coarse-grained, greenish-gray

Metasedimentary, Metavolcanic, and Transported Metaigneous Rocks

Station Hills Phyllite Member of Popes Head Formation (Cambrian) (Drake and Lyttle, 1981)—Light-greenish-gray, thin- to medium-bedded pelitic phyllite and lesser very fine-grained metasiltstone and chlorite-rich mafic metatuff. Has an apparent maximum thickness of about 300 m (984 ft)

Old Mill Branch Metasiltstone Member of Popes Head Formation (Cambrian) (Drake and Lyttle, 1981)—Light-greenish-gray, thin- to medium-bedded, medium- to very fine-grained, very mature, micaceous metasiltstone. The metasiltstone contains interbedded pelitic phyllite as well as felsic and mafic metatuff. Unit grades up into Station Hills Phyllite Member Єps), the contact being placed where more than 75 percent of the beds are pelitic phyllite. Unit has a maximum thickness of about 730 m (2,395 ft)

Piney Branch Complex (Early Cambrian and (or) Late Proterozoic) (Drake and Morgan, 1981)—Intermixed complex consisting of subequal parts of peridotite, pyroxenite, and gabbro now represented by serpentinite, soapstone, actinolite schist, and metagabbro which constitute an autoclastic melange. Contains small sheets and dikes of quartz-albite plagiogranite (ЄZp)

Yorkshire Formation (Early Cambrian and (or) Late Proterozoic) (Drake and Morgan, 1981)—Polygenetic melange consisting of a dark quartz-plagioclase-chlorite granofels matrix which contains chips, fragments, and small blocks of quartz, serpentinite, metagabbro, plagiogranite, mafic volcanics, and other exotic rock types. Characterized by abundant light-colored feldspar grains which contrast greatly with the dark phyllosilicate component, as well as by a scaly foliation

Peters Creek Schist (Early Cambrian and (or) Late Proterozoic) (Drake and Morgan, 1981)—Fine- to coarse-grained, lustrous, greenish-gray to gray, reddish-weathering, quartz-rich schist, and lesser mica gneiss. Fine- to medium-grained, light- to medium-gray, yellowish- to reddish-brown-weathering, well-bedded metagraywacke and semi-pelitic schist (ЄZpg). Both of these rock types contains abundant interbeds of the other rock type, as well as a few layers of calc-silicate rock. Much of the graywacke is graded, but some beds have a pseudolamination which is actually pressure-solution cleavage. Contains large mappable blocks of serpentinite and associated chlorite- tremolite-epidote schist, talc-chlorite schist, and talc-chlorite-actinolite schist (ЄZu). The unit's thickness is not known, as its base is marked by the Plummers Island thrust fault (Drake, 1985a). It is overlain on the west by Triassic rocks

Sykesville Formation (Early Cambrian and (or) Late Proterozoic) (Hopson, 1964; Drake, 1985a)—Light- to medium-gray, medium-grained sedimentary melange consisting of a quartzofeldspathic matrix that contains fragments of foliated felsic and mafic metavolcanic rocks, quartz, metagabbro, Peters Creek Schist, and ultramafic rocks. Shown in cross section only

Vertical

Strike and dip of foliation—Rocks of the Piney Branch Complex and Yorkshire Formation, and schistosity of indeterminate generation in other rocks
Inclined
Vertical

Strike and dip of phyllonitic foliation
Inclined
Vertical

Strike and dip of transposition foliation
Inclined
Vertical

Strike and dip of schistosity
Inclined
Vertical

Strike and dip of spaced schistosity
Inclined
Vertical

Strike and dip of crenulation cleavage or schistosity
Inclined

Strike and dip of joints
Inclined
Vertical

LINEAR FEATURES

(May be combined with planar features)

Bearing and plunge of mineral lineations
Bearing and plunge of intersections of bedding and schistosity
Bearing and plunge of microfolds in schistosity
Bearing and plunge of intersection of crenulation cleavage and schistosity

OTHER FEATURES

⚒ Quarry

INTRODUCTION

The Vienna 7.5-minute quadrangle is largely in north-central Fairfax County, Virginia but the extreme northeast corner is in Montgomery County, Maryland. Much of the quadrangle is urban, and development is proceeding rapidly throughout the area. Piedmont crystalline rocks of the central Appalachian internides underlie most of the quadrangle. Mesozoic sedimentary and intrusive igneous rocks crop out in the northwestern part of the quadrangle. Alluvium occurs along most streams and gravel terrace deposits occur along the Potomac River. Natural outcrops, many of which are saprolite, are largely restricted to stream valleys. Drake's knowledge of the northern Virginia crystalline rocks has been gained by abundant work in recent years (Drake, 1985a, 1985b, 1985c; 1986a, 1986b, 1986c; 1987; Drake and Froelich, 1986; Drake and Lyttle, 1981; Drake and Morgan, 1981, 1983; and Drake and others, 1979). Knowledge of the Mesozoic rocks was gained by the work of Drake and others (1979) and particularly by Lee and Froelich (1989). This work is briefly summarized below.

CRYSTALLINE ROCKS

Metamorphosed sedimentary rocks constitute most of the crystalline terrane in the Vienna quadrangle, but some volcanic and intrusive rocks are also present. Transported intrusive rocks are also fairly abundant. These rocks have been intruded by small bodies of Bear Island Granodiorite (Cloos and Cooke, 1953), quartz bodies, and one lamprophyre dike.

METASEDIMENTARY AND METAVOLCANIC ROCKS

The metasedimentary and metavolcanic rocks in this part of northern Virginia constitute a stack of four lithotectonic units (Drake and Lyttle, 1981; Drake and Morgan, 1981; Drake, 1985c, 1987). The youngest and highest of these units, the Popes Head Formation, unconformably overlies all the other units that constitute three thrust sheet-precursory melange pairs termed tectonic motifs (Drake, 1985a, 1985c). These motifs are, from highest to lowest, the Piney Branch-Yorkshire, the Peters Creek-Sykesville, and the Annandale-Indian Run. Only the Piney Branch-Yorkshire and the Peters Creek part of the Peters Creek-Sykesville motifs crop out in the Vienna quadrangle.

POPES HEAD FORMATION

The Popes Head Formation (Drake and Lyttle, 1981) unconformably overlies all the other lithotectonic units and consists of a lower Old Mill Branch Metasiltstone Member and an upper Station Hills Phyllite Member. Both members contain interbedded felsic and mafic metatuff. These rocks are interpreted to belong to Bouma's (1962) turbidite sequence T_{de} and to Mutti and Ricci Lucchi's (1978) turbidite facies D, suggesting deposition from weak turbidity flows (Drake and Lyttle, 1981). Drake and Lyttle (1981) have suggested that the formation may have resulted from the bilateral filling of a back-arc basin. Rocks of the Popes Head Formation contain the typical mineral assemblage of quartz-muscovite-biotite-plagioclase-chlorite, and the unit is at the biotite grade of metamorphism.

PINEY BRANCH—YORKSHIRE MOTIF

The Piney Branch Complex has been interpreted to be a fragment of a large dismembered ophiolite (Drake and Morgan, 1981). This complex lacks discernible order and is thought to be a tectonic melange resulting from the autoclastic deformation of a layered complex that contained repetitive cycles of ultramafic and mafic layers (Drake and Morgan, 1981). Mineralogic and chemical data for these rocks are presented in Drake and Morgan (1981). The ultramafic and mafic rocks within the complex have been retrogressively metamorphosed to mineral assemblages stable in the greenschist facies, and almost no original minerals survive. These ultramafic and mafic rocks are intruded by small dikes and sheets of leucocratic rocks having a color index of less than 2. They are composed of quartz and plagioclase and have Na_2O-K_2O ratios of more than 4 to 1. The petrographic and chemical data indicate that these rocks are similar to the metamorphosed plagiogranites of the Baltimore Complex of Maryland (Morgan, 1977) and to plagiogranites in other ophiolite complexes (Coleman and Peterman, 1975).

Sykesville does not crop out in the Vienna quadrangle, and the reader is referred to Drake (1985a), Drake and Lyttle (1981), and Drake and Morgan (1981) for a description of that unit and its relation to the Peters Creek Schist.

PRE-MESOZOIC INTRUSIVE ROCKS

The metasedimentary and metavolcanic rocks in the Vienna quadrangle contain sills of amphibolite, small bodies of Bear Island Granodiorite, one lamprophyre dike, and a few quartz bodies.

AMPHIBOLITE

Sills of epidote-plagioclase-hornblende amphibolite intrude the Peters Creek Schist. Some specimens contain relict clinopyroxene and have diabase textures. These sills are almost certainly metadiabase. Although foliated, only the smaller sills and the margins of the larger sills are schistose. We have only recently become aware of unpublished radiometric determinations on zircon from amphibolite on the southeastern tip of Bear Island in the Falls Church quadrangle (Fisher, 1971). These determinations gave a Pb^{207}-Pb^{206} age of 525±60 Ma, and a concordia age of 550 Ma, assuming continuous diffusion. Although there is a large error bar, these dates are consistent with the regional geology and the amphibolite is considered to be of Early Cambrian age. The sills appear to be restricted to rocks of the staurolite + andalusite or higher grade zones, suggesting that they were emplaced during metamorphism.

QUARTZ BODIES

Lenticular to irregularly shaped bodies of quartz occur within both the Peters Creek Schist and Popes Head Formation. It is impossible to date these bodies, but they are interpreted to result from metamorphic differentiation within the regime of greenschist-facies metamorphism. The bodies within the Peters Creek Schist probably formed during both the early prograde and retrograde events. The body within the Popes Head Formation is interpreted to date from the prograde metamorphic event experienced by that unit.

BEAR ISLAND GRANODIORITE

Leucocratic granitoid rock forms dikes, sheets, and small irregularly shaped intrusive bodies within the high-grade part of the Peters Creek Schist from Bear Island in the Potomac River south to the overlap of Mesozoic rocks in the Manassas quadrangle (Drake and others, 1979). Similar rocks have been recognized at least as far northeast as the Patuxent River in the Woodbine 7.5-minute quadrangle in Maryland (A.A. Drake, Jr., unpub. data). The composition of these rocks varies, and they have been termed granodiorite, leucotonalite, adamellite, quartz diorite, and quartz monzonite. Cloos and Cook (1953) formally named these intrusive rocks the Bear Island Granodiorite. Hopson (1964) called the suite Bear Island Granite because of its silicic composition and because its plagioclase is albite; Drake (1986a, 1987) followed Hopson's usage. Modal data (fig. 1) are equally divided between the monzogranite, granodiorite, and tonalite fields. Most of the monzogranites, however, plot near the granodiorite field and petrographically, granodiorite appears to be the best name for these rocks. Chemically (table 1), however, most of the rocks are trondhjemite (fig. 2), and closely resemble the oceanic trondhjemites of Fiji (Gill and Stork, 1979). In any case, granodiorite appears to be the most useful rock name, although the Bear Island rocks contain more Na_2O and much less K_2O and MgO than typical granodiorites (Nockolds, 1954). More work needs to be done on these interesting rocks, but such a study will be hindered by the difficulty of finding suitable material away from the Potomac River. The name Bear Island Granodiorite is herein accepted for use by the U.S. Geological Survey.

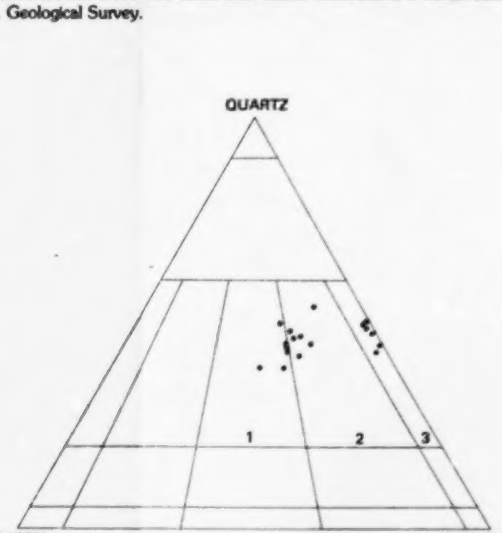


Figure 1.—Quartz-alkali feldspar-plagioclase (Streckeisen, 1976) plot of Bear Island Granodiorite. Represented fields are: 1. monzogranite; 2. granodiorite; and 3. tonalite

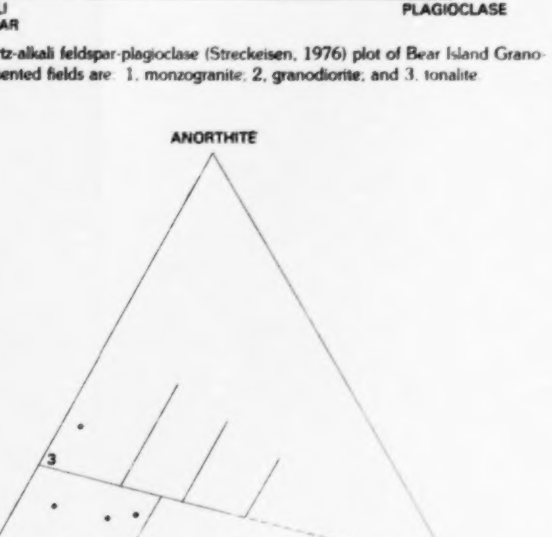


Figure 2.—Normative feldspar (O'Connor, 1965) plot of Bear Island Granodiorite. Represented fields are: 1, trondhjemite; 2, granite; and 3, tonalite.

Table 1.—Chemical analyses and C.I.P.W. norms of the Bear Island Granodiorite (weight percent)

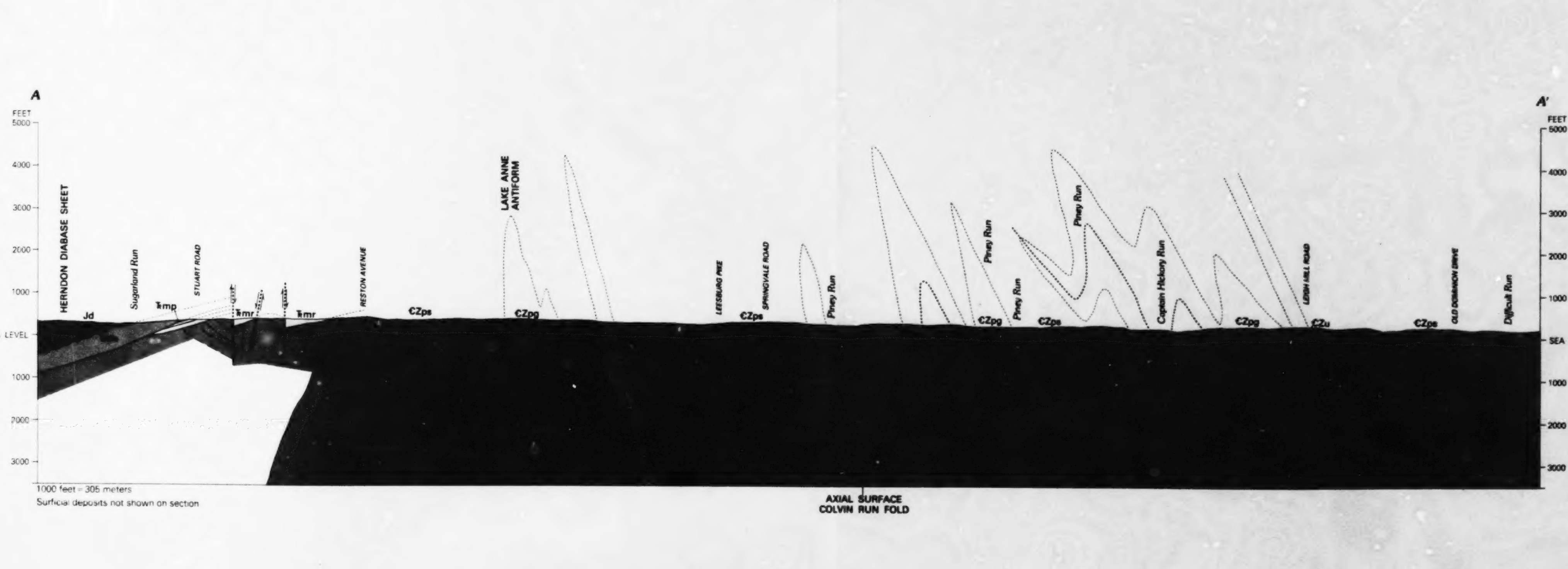
Sample No.	1	2	3	4	5	6	7	8	9	10	11
SiO_2	74.9	76.6	75.5	76.2	74.0	58.1	68.4	77.2	75.4	74.0	77.01
Al_2O_3	14.2	14.3	14.7	13.5	13.8	25.5	18.5	13.3	13.8	14.5	13.47
Fe_2O_3	1.9	0.51	0.32	0.8	0.32	0.13	0.65	0.13	0.29	0.73	0.48
FeO	0.16	0.20	0.40	0.36	0.24	0.88	0.34	0.7	0.24	0.20	1.15
MgO	0.17	0.20	0.18	0.37	0.29	0.36	0.42	0.29	0.19	0.15	0.15
CaO	1.3	0.31	0.81	1.2	0.95	6.5	2.4	0.22	0.62	0.66	0.53
Na_2O	3.9	5.1	5.1	3.4	3.1	6.7	6.6	4.4	3.1	6.1	3.69
K_2O	1.9	1.5	1.6	2.2	5.5	0.7	0.88	2.0	5.2	1.4	2.18
H_2O+	0.65	0.6	0.88	0.76	0.14	0.72	0.62	0.74	0.59	0.52	0.89
H_2O-	0.09	0.11	0.11	0.12	0.86	0.1	0.14	–	–	0.21	0.01
TiO_2	0.04	0.08	0.08	0.19	0.11	0.17	0.19	0.09	0.07	0.04	0.10
P_2O_5	0.21	0.08	0.2	–	0.11	0.11	0.11	0.14	0.1	0.12	0.06
MnO	0.06	0.08	0.04	0.08	0.10	0.1	0.07	0.06	0.03	0.04	0.13
CO_2	.41	0.05	0.05	0.26	0.08	0.08	0.05	0.05	0.05	0.04	0.13
Total	99.89	99.72	99.97	99.44	99.60	100.15	99.35	99.32	98.68	98.71	99.98
C.I.P.W. Norms (weight percent)											
Quartz	42.7	41.7	38.2	46.6	32.6	1.4	21.5	43.3	36.5	32.6	45.8
Orthoclase	11.1	8.9	9.4	12.8	33.4	3.9	5.6	11.7	30.6	8.3	12.8
Albite	34.1	43.0	44.0	29.3	27.2	57.6	56.6	38.2	26.2	52.4	31.4
Anorthite	5.6	0.6	3.1	5.8	3.9	32.0	11.1	0.8	3.3	2.5	2.5
Corundum	3.7	4.2	3.5	3.5	1.1	2.0	2.6	3.6	1.9	2.1	4.2
Diopside	0.4	0.5	0.8	1.0	0.8	2.3	1.1	1.9	0.5	0.4	2.2
Wollastonite	–	–	–	–	–	–	–	–	–	–	–
Hypersthene	–	–	–	–	–	–	–	–	–	–	–
Magnetite	0.7	0.7	0.5	0.7	0.5	0.2	0.5	0.2	0.5	0.7	0.7
Apatite	0.3	0.3	0.3	–	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Ilmenite	–	0.2	0.2	0.5	0.2	0.3	0.5	0.2	0.2	0.3	0.2
Titanite	–	–	–	–	–	–	–	–	–	–	–
Hematite	1.4	–	–	0.3	–	–	0.3	–	–	0.2	–
Total	100.0	100.1	100.0	100.5	100.0	100.0	100.1	100.2	100.0	99.8	100.1

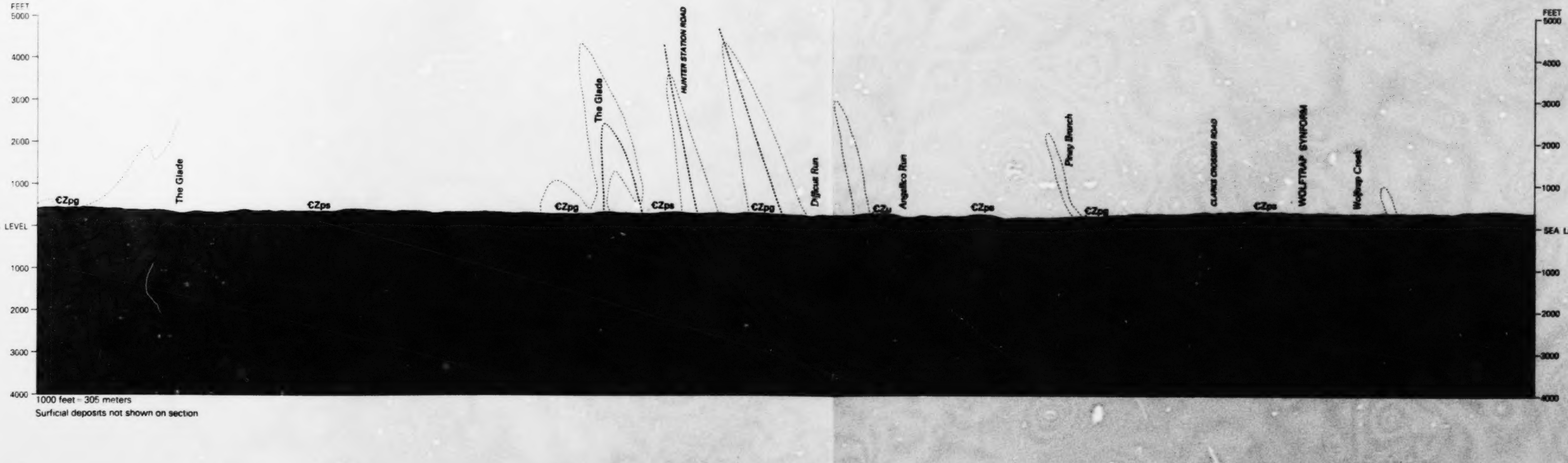
Rapid rock analyses by P. Elmore, S. Botts, H. Smith, G. Chloe, J. Kelsey, J. Glenn, and L. Artis, USGS, Samples 1–7; P. Elmore, I.H. Barlow, S. Botts, and G. Chloe, USGS, Samples 8–9, and K. Coates and H. Smith, USGS, (Sample 10). Sample 11 from Hopson (1964)

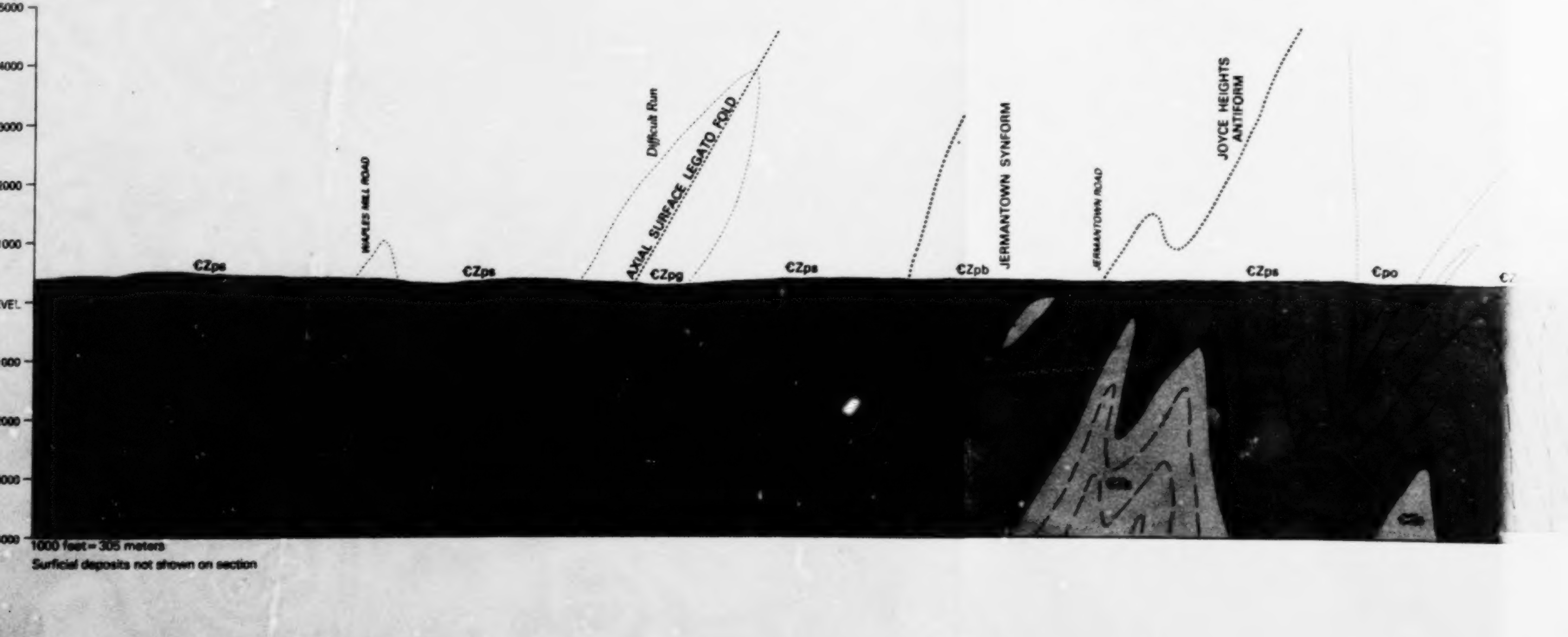
Description of samples

All samples from the Falls Church 7.5-minute quadrangle except when noted

1. Light-colored granodiorite dike cutting migmatitic schist. Southern part of Bear Island
2. Light-colored granodiorite dike cutting calc-silicate gneiss. Southern part of Bear Island
3. Light-colored granodiorite dike cutting calc-silicate gneiss. Southern part of Bear Island
4. Light-colored granodiorite cutting migmatitic schist. Northern part of Bear Island
5. Monzogranite stock cutting migmatitic schist. Northern part of Bear Island
6. Diorite dike cutting amphibolite. Northern part of Bear Island
7. Tonalite dike cutting amphibolite. Southern part of Bear Island
8. Granodiorite sheet cutting schist. Sherwin Island.
9. Large monzogranite stock cutting migmatitic schist and amphibolite. Northern part of Bear Island
10. Light-colored granodiorite sheet cutting schist. Cut along Southern Railroad about 363 m (1,200 ft) southwest from trestle across Bull Run, Manassas 7.5-minute quadrangle, Va.
11. Biotite-muscovite granodiorite. Western end of Bear Island (Hopson, 1964)

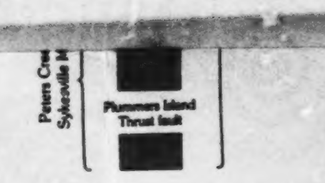






GEOLOGIC MAP OF THE VIENNA QUADRANGLE, FAIRFAX COUNTY, VIRGINIA, AND MONTGOMERY COUNTY, MARYLAND

By
Avery Ala Drake, Jr., and K.Y. Lee
1989



DESCRIPTION OF MAP UNITS

SURFICIAL DEPOSITS

Artificial fill—Various sandy and gravelly materials; occupies low-lying areas filled for construction of highways, bridges, and railroad beds

Qal **Alluvium (Holocene)**—Sand, gravel, silt, and clay underlying sinuous flood plains along most streams; clastic sediments are in fairly well-bedded, well- to poorly sorted, graded fluvial, cyclic deposits with gravel at base of upward fining sequences; as much as 7 m (23 ft thick). Commonly micaceous silts and sands with quartz and crystalline rock pebbles, cobbles, and boulders in streams draining Piedmont terrain

Qt **Terrace deposits (Holocene (?))**—Gravel, sand, silt, and clay deposits along Potomac River

MESOZOIC ROCKS

Diabase (Early Jurassic)—Medium- to dark-gray; largely equigranular, locally microcrystalline to fine-crystalline near the chilled margins, but coarse-crystalline in central parts of larger bodies. Consists of grayish-green to black crystals of augite and pigeonite and scattered granules or aggregates of magnetite and ilmenite which fill interstices between euhedral and subhedral light-gray plagioclase laths. Forms the Herndon sheet and a dike in the northwestern corner of the quadrangle

Thermally metamorphosed rocks (Late Triassic)—Gray to dark-gray, medium-bluish-gray, and olive-black hornfels and granofels which are metamorphosed sandstone of the Poolesville Member of the Manassas Sandstone. Cordierite hornfels and tourmaline granofels are the major rock types in the metamorphic aureole beneath the Herndon diabase sheet

TRmp **Poolesville Member of Manassas Sandstone (Late Triassic) (Lee and Froelich, 1989)**—Dusky-red to grayish-red to very dark-red, very fine- to medium-grained feldspathic, micaceous, ferruginous sandstone. Thin- to very thick-bedded and massive, and planar crossbedded. Locally it contains lenses and beds of light-gray to gray, medium- to very coarse-grained, feldspathic sandstone and quartzite pebble conglemerate. Thickness is variable but may exceed 1 km (3,281 ft) in places

TRmr **Reston Member of Manassas Sandstone (Late Triassic) (Lee and Froelich, 1989)**—Predominantly pebble to boulder conglomerate containing subangular clasts of schists, quartz, and quartzite in a matrix of fine- to coarse-grained arkosic sand or clayey silt. Contains some beds of micaceous, calcareous, clayey, feldspathic siltstone, fine- to medium-grained crossbedded sandstone; and pebbly, feldspathic, coarse-grained sandstone. In this quadrangle the unit ranges from 3 m (10 ft) to 30 m (98.5 ft) in thickness

PIEDMONT ROCKS

Intrusive Rocks

Dl **Lamprophyre (Late Devonian)**—Fine-grained, dark-greenish-gray, biotite-quartz-plagioclase dike

Bear Island Granodiorite (Ordovician(?)) (Cloos and Cooke, 1953)—Fine-grained, very leucocratic, muscovite-biotite granodiorite and related pegmatite composed largely of quartz, albite, and microcline. Forms small- to moderate-sized sheets and crosscutting bodies. Found only within Peters Creek Schist (€Zps and €CZpg)

Quartz bodies (Cambrian)—Lenticular bodies or irregular masses. Some bodies are foliated or polyfoliated, whereas others are massive

Amphibolite (Lower Cambrian)—Fine- to coarse-grained, greenish-gray

Metasedimentary, Metavolcanic, and Transported Metaigneous Rocks

Station Hills Phyllite Member of Popes Head Formation (Cambrian) (Drake and Lyttle, 1981)—Light-greenish-gray, thin- to medium-bedded pelitic phyllite and lesser very fine-grained metasiltstone and chlorite-rich mafic metatuff. Has an apparent maximum thickness of about 300 m (984 ft)

Old Mill Branch Metasiltstone Member of Popes Head Formation (Cambrian) (Drake and Lyttle, 1981)—Light-greenish-gray, thin- to medium-bedded, medium- to very fine-grained, very mature, micaceous metasiltstone. The metasiltstone contains interbedded pelitic phyllite as well as felsic and mafic metatuff. Unit grades up into Station Hills Phyllite Member €ps), the contact being placed where more than 75 percent of the beds are pelitic phyllite. Unit has a maximum thickness of about 730 m (2,395 ft)

Piney Branch Complex (Early Cambrian and (or) Late Proterozoic) (Drake and Morgan, 1981)—Intermixed complex consisting of subequal parts of peridotite, pyroxenite, and gabbro now represented by serpentinite, soapstone, actinolite schist, and metagabbro which constitute an autoclastic melange. Contains small sheets and dikes of quartz-albite plagiogranite (€Zp)

Yorkshire Formation (Early Cambrian and (or) Late Proterozoic) (Drake and Morgan, 1981)—Polygenetic melange consisting of a dark quartz-plagioclase-chlorite granofels matrix which contains chips, fragments, and small blocks of quartz, serpentinite, metagabbro, plagiogranite, mafic volcanics, and other exotic rock types. Characterized by abundant light-colored feldspar grains which contrast greatly with the dark phyllosilicate component, as well as by a scaly foliation

Peters Creek Schist (Early Cambrian and (or) Late Proterozoic) (Drake and Morgan, 1981)—Fine- to coarse-grained, lustrous, greenish-gray to gray, reddish-weathering, quartz-rich schist, and lesser mica gneiss. Fine- to medium-grained, light- to medium-gray, yellowish- to reddish-brown-weathering, well-bedded metagraywacke and semi-pelitic schist (€Zpg). Both of these rock types contains abundant interbeds of the other rock type, as well as a few layers of calc-silicate rock. Much of the graywacke is graded, but some beds have a pseudolamination which is actually pressure-solution cleavage. Contains large mappable blocks of serpentinite and associated chlorite- tremolite-epidote schist, talc-chlorite schist, and talc-chlorite-actinolite schist (€Zu). The unit's thickness is not known, as its base is marked by the Plummers Island thrust fault (Drake, 1985a). It is overlain on the west by Triassic rocks

€Zs **Sykesville Formation (Early Cambrian and (or) Late Proterozoic) (Hopson, 1964; Drake, 1985a)**—Light- to medium-gray, medium-grained sedimentary melange consisting of a quartzofeldspathic matrix that contains fragments of foliated felsic and mafic metavolcanic rocks, quartz, metagabbro, Peters Creek Schist, and ultramafic rocks. Shown in cross section only

Vertical

Strike and dip of foliation—Rocks of the Piney Branch Complex and Yorkshire Formation, and schistosity of indeterminate generation in other rocks
Inclined
Vertical

Strike and dip of phyllonitic foliation
Inclined
Vertical

Strike and dip of transposition foliation
Inclined
Vertical

Strike and dip of schistosity
Inclined
Vertical

Strike and dip of spaced schistosity
Inclined
Vertical

Strike and dip of crenulation cleavage or schistosity
Inclined

Strike and dip of joints
Inclined
Vertical

LINEAR FEATURES

(May be combined with planar features)

Bearing and plunge of mineral lineations
Bearing and plunge of intersections of bedding and schistosity
Bearing and plunge of microfolds in schistosity
Bearing and plunge of intersection of crenulation cleavage and schistosity

OTHER FEATURES

⚒ Quarry

INTRODUCTION

The Vienna 7.5-minute quadrangle is largely in north-central Fairfax County, Virginia but the extreme northeast corner is in Montgomery County, Maryland. Much of the quadrangle is urban, and development is proceeding rapidly throughout the area. Piedmont crystalline rocks of the central Appalachian internides underlie most of the quadrangle. Mesozoic sedimentary and intrusive igneous rocks crop out in the northwestern part of the quadrangle. Alluvium occurs along most streams and gravel terrace deposits occur along the Potomac River. Natural outcrops, many of which are saprolite, are largely restricted to stream valleys. Drake's knowledge of the northern Virginia crystalline rocks has been gained by abundant work in recent years (Drake, 1985a, 1985b, 1985c; 1986a, 1986b, 1986c; 1987; Drake and Froelich, 1986; Drake and Lyttle, 1981; Drake and Morgan, 1981, 1983; and Drake and others, 1979). Knowledge of the Mesozoic rocks was gained by the work of Drake and others (1979) and particularly by Lee and Froelich (1989). This work is briefly summarized below.

CRYSTALLINE ROCKS

Metamorphosed sedimentary rocks constitute most of the crystalline terrane in the Vienna quadrangle, but some volcanic and intrusive rocks are also present. Transported intrusive rocks are also fairly abundant. These rocks have been intruded by small bodies of Bear Island Granodiorite (Cloos and Cooke, 1953), quartz bodies, and one lamprophyre dike.

METASEDIMENTARY AND METAVOLCANIC ROCKS

The metasedimentary and metavolcanic rocks in this part of northern Virginia constitute a stack of four lithotectonic units (Drake and Lyttle, 1981; Drake and Morgan, 1981; Drake, 1985c, 1987). The youngest and highest of these units, the Popes Head Formation, unconformably overlies all the other units that constitute three thrust sheet-precursory melange pairs termed tectonic motifs (Drake, 1985a, 1985c). These motifs are, from highest to lowest, the Piney Branch-Yorkshire, the Peters Creek-Sykesville, and the Annandale-Indian Run. Only the Piney Branch-Yorkshire and the Peters Creek part of the Peters Creek-Sykesville motifs crop out in the Vienna quadrangle.

POPES HEAD FORMATION

The Popes Head Formation (Drake and Lyttle, 1981) unconformably overlies all the other lithotectonic units and consists of a lower Old Mill Branch Metasiltstone Member and an upper Station Hills Phyllite Member. Both members contain interbedded felsic and mafic metatuff. These rocks are interpreted to belong to Bouma's (1962) turbidite sequence T_{de} and to Mutti and Ricci Lucchi's (1978) turbidite facies D, suggesting deposition from weak turbidity flows (Drake and Lyttle, 1981). Drake and Lyttle (1981) have suggested that the formation may have resulted from the bilateral filling of a back-arc basin. Rocks of the Popes Head Formation contain the typical mineral assemblage of quartz-muscovite-biotite-plagioclase-chlorite, and the unit is at the biotite grade of metamorphism.

PINEY BRANCH—YORKSHIRE MOTIF

The Piney Branch Complex has been interpreted to be a fragment of a large dismembered ophiolite (Drake and Morgan, 1981). This complex lacks discernible order and is thought to be a tectonic melange resulting from the autoclastic deformation of a layered complex that contained repetitive cycles of ultramafic and mafic layers (Drake and Morgan, 1981). Mineralogic and chemical data for these rocks are presented in Drake and Morgan (1981). The ultramafic and mafic rocks within the complex have been retrogressively metamorphosed to mineral assemblages stable in the greenschist facies, and almost no original minerals survive. These ultramafic and mafic rocks are intruded by small dikes and sheets of leucocratic rocks having a color index of less than 2. They are composed of quartz and plagioclase and have Na_2O-K_2O ratios of more than 4 to 1. The petrographic and chemical data indicate that these rocks are similar to the metamorphosed plagiogranites of the Baltimore Complex of Maryland (Morgan, 1977) and to plagiogranites in other ophiolite complexes (Coleman and Peterman, 1975).

(1985a), Drake and Lyttle (1981), and Drake and Morgan (1981) for a description of that unit and its relation to the Peters Creek Schist.

PRE-MESOZOIC INTRUSIVE ROCKS

The metasedimentary and metavolcanic rocks in the Vienna quadrangle contain sills of amphibolite, small bodies of Bear Island Granodiorite, one lamprophyre dike, and a few quartz bodies.

AMPHIBOLITE

Sills of epidote-plagioclase-hornblende amphibolite intrude the Peters Creek Schist. Some specimens contain relict clinopyroxene and have diabase textures. These sills are almost certainly metadiabase. Although foliated, only the smaller sills and the margins of the larger sills are schistose. We have only recently become aware of unpublished radiometric determinations on zircon from amphibolite on the southeastern tip of Bear Island in the Falls Church quadrangle (Fisher, 1971). These determinations gave a Pb^{207}-Pb^{206} age of 525±60 Ma, and a concordia age of 560 Ma, assuming continuous diffusion. Although there is a large error bar, these dates are consistent with the regional geology and the amphibolite is considered to be of Early Cambrian age. The sills appear to be restricted to rocks of the staurolite + andalusite or higher grade zones, suggesting that they were emplaced during metamorphism.

QUARTZ BODIES

Lenticular to irregularly shaped bodies of quartz occur within both the Peters Creek Schist and Popes Head Formation. It is impossible to date these bodies, but they are interpreted to result from metamorphic differentiation within the regime of greenschist-facies metamorphism. The bodies within the Peters Creek Schist probably formed during both the early prograde and retrograde events. The body within the Popes Head Formation is interpreted to date from the prograde metamorphic event experienced by that unit.

BEAR ISLAND GRANODIORITE

Leucocratic granitoid rock forms dikes, sheets, and small irregularly shaped intrusive bodies within the high-grade part of the Peters Creek Schist from Bear Island in the Potomac River south to the overlap of Mesozoic rocks in the Manassas quadrangle (Drake and others, 1979). Similar rocks have been recognized at least as far northeast as the Patuxent River in the Woodbine 7.5-minute quadrangle in Maryland (A.A. Drake, Jr., unpub. data). The composition of these rocks varies, and they have been termed granodiorite, leucotonalite, adamellite, quartz diorite, and quartz monzonite. Cloos and Cook (1953) formally named these intrusive rocks the Bear Island Granodiorite. Hopson (1964) called the suite Bear Island Granite because of its silicic composition and because its plagioclase is albite; Drake (1986a, 1987) followed Hopson's usage. Modal data (fig. 1) are equally divided between the monzogranite, granodiorite, and tonalite fields. Most of the monzogranites, however, plot near the granodiorite field and petrographically, granodiorite appears to be the best name for these rocks. Chemically (table 1), however, most of the rocks are trondhjemite (fig. 2), and closely resemble the oceanic trondhjemites of Fiji (Gill and Stork, 1979). In any case, granodiorite appears to be the most useful rock name, although the Bear Island rocks contain more Na_2O and much less K_2O and MgO than typical granodiorites (Nockolds, 1954). More work needs to be done on these interesting rocks, but such a study will be hindered by the difficulty of finding suitable material away from the Potomac River. The name Bear Island Granodiorite is herein accepted for use by the U.S. Geological Survey.

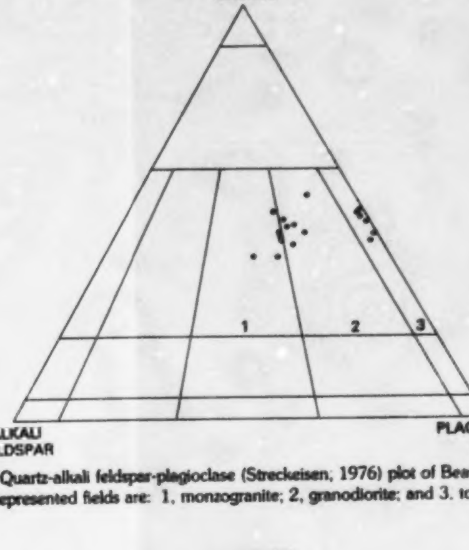


Figure 1.—Quartz-alkali feldspar-plagioclase (Streckeisen, 1976) plot of Bear Island Granodiorite. Represented fields are: 1, monzogranite; 2, granodiorite; and 3, tonalite.

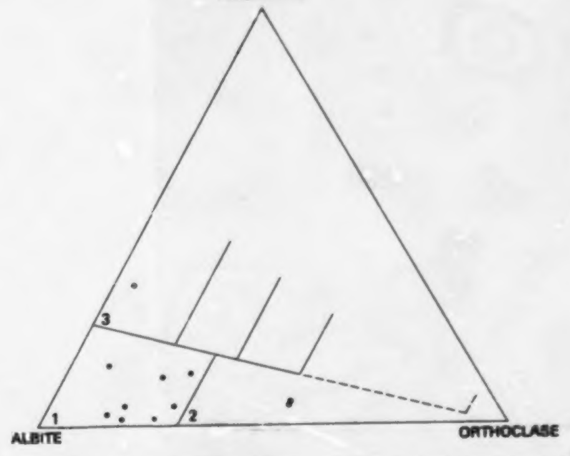


Figure 2.—Normative feldspar (O'Connor, 1965) plot of Bear Island Granodiorite. Represented fields are: 1, trondhjemite; 2, granite; and 3, tonalite.

DIABASE

The Vienna quadrangle contains the eastern part of the Herndon diabase sheet, which has an average thickness of about 200 m (656 ft), as well as the southernmost dike of the north-northeast-trending Seneca system (Froelich and Gottfried, in press). Chemically, the diabase is a high (1.0–1.2 percent) TiO_2, quartz-normative (51–53 percent SiO_2) tholeiite of the York Haven type, and belongs to the east-central lineage of Froelich and Gottfried (in press). Diabase within the Culpeper basin is considered to have a mean age of 198.4±2.1 Ma based on ^{40}Ar-^{39}Ar determinations on several whole-rock samples (Sutter, 1985).

AGES OF THE METASEDIMENTARY, METAVOLCANIC, AND METAINTRUSIVE ROCKS

The ages of the metasedimentary, metavolcanic, and metaintrusive rocks cannot be directly determined, and depend on the age of the Occoquan Granite, which crops out in the adjacent Fairfax and Annandale 7.5-minute quadrangles (Drake, 1986a; Drake and Froelich, 1986). The Occoquan is Cambrian in age (Seiders and others, 1975; Mose and Nagel, 1982), and intrudes the Popes Head Formation (Drake, 1986a, 1987; Drake and Froelich, 1986; Drake and Lyttle, 1981). The Popes Head Formation unconformably overlies the Peters Creek Schist, the Yorkshire Formation, and the Piney Branch Complex; all these rocks thus are Cambrian or older. The Popes Head Formation is thought to be Cambrian in age (Drake, 1986a, 1987; Drake and Froelich, 1986). The Peters Creek Schist, Yorkshire Formation, and Piney Branch Complex have had much more complicated structural and metamorphic histories, suggesting that they may be older and possible Late Proterozoic in age. This, however, cannot be proved, and these rocks must be considered Early Cambrian and (or) Late Proterozoic in age.

STRUCTURAL GEOLOGY

The Popes Head Formation was deposited on the already assembled stack of Piney Branch-Yorkshire and Peters Creek-Sykesville Motifs. Subsequently, the stack of motifs and the Popes Head Formation were folded together. Fold phases in this quadrangle, following the usage of Tobisch and Fleuty (1969), have been named for geographic locations where they are well displayed or for the major fold of a particular phase (table 2). This was done because all fold phases are not necessarily everywhere present and numerical chronology could become confusing.

First phase folds in both the Peters Creek Schist and Popes Head Formation have an axial surface schistosity. These schistosities are not the same age, however, because the Popes Head Formation was not deposited until the Peters Creek Schist was folded three times and phyllonitized in its eastern area of outcrop. Other planar structures mapped in the Peters Creek Schist include transposition foliation (bedding totally transposed into Captain Hickory phase schistosity), spaced schistosity (Potomac phase), crenulation cleavage (Reston phase), and phyllonitic foliation. Phyllonitic foliation appears to be the result of the transposition of earlier planar elements into a fourth phase spaced schistosity. It was impossible at many places, particularly in saprolite, to identify planar elements within the Peters Creek Schist. A foliation symbol is shown at such places on the map.

FOLDS IN THE POPES HEAD FORMATION

The Clifton is the oldest fold phase in the Popes Head Formation. It was named for the Clifton syncline (Drake, 1986a, 1987), the northern terminus of which is in the Falls Church 7.5-minute quadrangle. The characteristics of Clifton folds are given in table 2. Two smaller synclines cored with Popes Head Formation in the southern part of the Vienna quadrangle are also Clifton folds.

The outcrop pattern of the Popes Head Formation in the Fairfax and Manassas quadrangles to the south, as well as direct observations in the field and structural-geometric analysis (Drake, 1986a, 1987), show that Clifton schistosity and folds are folded about more northerly trending axes. These folds were named Accotink Creek for the creek of that name in the northern part of the Fairfax quadrangle (Drake, 1986a, 1987). They are nearly coaxial and coplanar with Clifton folds, and at many places bedding and Clifton schistosity are transposed into a spaced schistosity that is axial planar to Accotink Creek folds (table 2). For these reasons, Accotink Creek folds are difficult to recognize in the field. This recognition is further complicated by the tendency for earlier fold axes to rotate into parallelism with later axes if the intermediate strain axis of the later deformation field is inclined less than 30° from that of the earlier intermediate strain axis (Ghosh and Ramberg, 1968). Accotink Creek folds are interpreted to have resulted from progressive deformation within a stress continuum during progressive regional dynamic metamorphism (Drake, 1987). Major Accotink Creek folds affecting the Popes Head Formation in this quadrangle are the Vienna syncline and the Cunningham Park anticline.

FOLDS IN THE PINEY BRANCH—YORKSHIRE MOTIF

In the Fairfax and Manassas quadrangles to the south, previously deformed rocks of the Piney Branch Complex and Yorkshire Formation are folded with the Popes Head Formation in the major Clifton-phase (table 2) Jermantown synform (Drake, 1986a, 1987; Drake and others, 1979). Farther north, the Popes Head unconformity cuts down onto the Peters Creek Schist. The Peters Creek is exposed below the Piney Branch-Yorkshire motif to the northern terminus of the Jermantown synform in this quadrangle. Outlying bodies of the motif core four small subsidiary Clifton-phase synforms. No later fold phases were recognized in these rocks in the Vienna quadrangle.

FOLDS IN THE PETERS CREEK SCHIST

Deformation in the Peters Creek Schist is quite complex and at most places bedding and first-generation schistosity are nearly parallel, forming the tectonic surface called "bedding schistosity" by Hopson (1964). At many places, as recognized by Fisher (1963, 1970), small fold hinges of bedding can be found tucked within the schistosity; these folds are Fisher's F_2 folds. Many of these hinges plunge down the dip of later schistosity, but others have apparently been rotated into parallelism with later folds. This relation is geometrically shown on figure 3A. Here small fold axes and the intersections of bedding and schistosity plot on a great circle girdle, indicating refolding of earlier formed lineations. Many of those lineations plunge very steeply, and very many plunge more than 40°. Heretofore mappable first folds have not been recognized in the Peters Creek Schist. The distribution of metagraywacke in low-grade rocks in the Seneca 7.5-minute quadrangle to the north (Drake and others, 1979) indicate that a major early fold there trends somewhat north of west, and that it has been contracted by later nearly north-trending folds. In the Vienna quadrangle three areas of metagraywacke define fold axes that have been severely contracted by later folding, like the more straightforward example in the Seneca quadrangle. This interpretation is supported by a limited number of basin and dome fold-interference patterns seen in outcrop. Such patterns result from the near right-angle intersection of fold systems. The five early folds are the Captain Hickory, Colvin Run, Hunter, Glade, and Legato folds, and this phase is herein named the Captain Hickory phase for the fold along Captain Hickory Run in the northeastern part of the quadrangle. These folds are isoclinal and it is not known in which direction they close. The regional schistosity, the "bedding schistosity" of Hopson (1964) and Fisher (1963, 1970), is axial surface to these folds (table 2). It is interesting to note that Fisher (1970) found that the few early folds that he could measure trended about east-west.

Table 1.—Chemical analyses and C.I.P.W. norms of the Bear Island Granodiorite (weight percent)

Sample No.	1	2	3	4	5	6	7	8	9	10	11
SiO_2	74.9	76.6	75.5	76.2	74.0	58.1	68.4	77.2	75.4	74.0	77.01
Al_2O_3	14.2	14.3	14.7	13.5	13.8	25.5	18.5	13.3	13.8	14.5	13.47
Fe_2O_3	1.9	0.51	0.32	0.8	0.32	0.13	0.65	0.13	0.29	0.73	0.48
FeO	0.16	0.20	0.40	0.36	0.24	0.88	0.32	0.7	0.24	0.20	1.15
MgO	0.17	0.20	0.18	0.37	0.29	0.36	0.42	0.29	0.19	0.15	0.15
CaO	1.3	0.31	0.81	1.2	0.95	6.5	2.4	0.22	0.62	0.66	0.53
Na_2O	3.9	5.1	5.1	3.4	3.1	6.7	6.6	4.4	3.1	6.1	3.69
K_2O	1.9	1.5	1.6	2.2	5.5	0.7	0.88	2.0	5.2	1.4	2.18
H_2O+	0.65	0.6	0.88	0.76	0.14	0.72	0.62	0.74	0.59	0.52	0.89
H_2O-	0.09	0.11	0.11	0.12	0.86	0.1	0.14	–	–	0.21	0.01
TiO_2	0.04	0.08	0.08	0.19	0.11	0.17	0.19	0.09	0.07	0.04	0.10
P_2O_5	0.21	0.08	0.2	–	0.11	0.11	0.11	0.14	0.1	0.12	0.06
MnO	0.06	0.08	0.04	0.08	0.10	0.1	0.07	0.06	0.03	0.04	0.13
CO_2	.41	0.05	0.05	0.26	0.08	0.08	0.05	0.05	0.06	0.04	0.13
Total	99.89	99.72	99.97	99.44	99.60	100.15	99.35	99.32	98.68	98.71	99.98
C.I.P.W. Norms (weight percent)											
Quartz	42.7	41.7	38.2	46.6	32.6	1.4	21.5	43.3	36.5	32.6	45.8
Orthoclase	11.1	8.9	9.4	12.8	33.4	3.9	5.6	11.7	30.6	8.3	12.8
Albite	34.1	43.0	44.0	29.3	27.2	57.6	56.6	38.2	26.2	52.4	31.4
Anorthite	5.6	0.6	3.1	5.8	3.9	32.0	11.1	0.8	3.3	2.5	2.5
Corundum	3.7	4.2	3.5	3.5	1.1	2.0	2.6	3.6	1.9	2.1	4.2
Diopside	0.4	0.5	0.8	1.0	0.8	2.3	1.1	1.9	0.5	0.4	2.2
Wollastonite	–	–	–	–	–	–	–	–	–	–	–
Hypersthene	–	–	–	–	–	–	–	–	–	–	–
Magnetite	0.7	0.7	0.5	0.7	0.5	0.2	0.5	0.2	0.5	0.7	0.7
Apatite	0.3	0.3	0.3	–	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Ilmenite	–	0.2	0.2	0.5	0.2	0.3	0.5	0.2	0.2	0.3	0.2
Titanite	–	–	–	–	–	–	–	–	–	–	–
Hematite	1.4	–	–	0.3	–	–	0.3	–	–	0.2	–
Total	100.0	100.1	100.0	100.5	100.0	100.0	100.1	100.2	100.0	99.8	100.1

Rapid rock analyses by P. Elmore, S. Botts, H. Smith, G. Chloe, J. Kelsey, J. Glenn, and L. Artis, USGS, Samples 1–7; P. Elmore, I.H. Barlow, S. Botts, and G. Chloe, USGS, Samples 8–9; and K. Coates and H. Smith, USGS, (Sample 10). Sample 11 from Hopson (1964).

Description of samples

All samples from the Falls Church 7.5-minute quadrangle except when noted

1. Light-colored granodiorite dike cutting migmatitic schist. Southern part of Bear Island
2. Light-colored granodiorite dike cutting calc-silicate gneiss. Southern part of Bear Island
3. Light-colored granodiorite dike cutting calc-silicate gneiss. Southern part of Bear Island
4. Light-colored granodiorite dike cutting migmatitic schist. Northern part of Bear Island
5. Monzogranite stock cutting migmatitic schist. Northern part of Bear Island
6. Diorite dike cutting amphibolite. Northern part of Bear Island
7. Tonalite dike cutting amphibolite. Southern part of Bear Island
8. Granodiorite sheet cutting schist. Sherwin Island.
9. Large monzogranite sheet cutting schist and amphibolite. Northern part of Bear Island
10. Light-colored granodiorite sheet cutting schist. Cut along Southern Railroad about 363 m (1,200 ft) southwest from trestle across Bull Run, Manassas 7.5-minute quadrangle, Va.
11. Biotite-muscovite granodiorite. Western end of Bear Island (Hopson, 1964)

Table 2.—Fold phases in the Vienna 7.5-minute quadrangle

PHASE	TREND	FOLIATION	LINEATION	STYLE
Accotink Creek	North-northeast	Spaced schistosity	Intersections with earlier schistosity	Tight, upright to isoclinal overturned. Are nearly coaxial and coplanar with Clifton folds and cannot be mapped unless Clifton folds are recognized. Fold bedding and schistosity of the Popes Head Formation and phyllonitic foliation in Peters Creek Schist. Plunge either northeast or southwest
Clifton	Northeast	Phyllitic schistosity in Popes Head Formation	Intersection with bedding in Popes Head Formation	Isoclinal overturned to tight upright. Have long planar limbs and most have interlimb angles of less than 50°. Fold bedding in Popes Head Formation and schistosity and phyllonitic foliation in the Peters Creek Schist
Reston	Northwest	Crenulation cleavage	Intersection with Captain Hickory schistosity and Potomac spaced schistosity	Tight isoclinal. Only two folds large enough to map in this quadrangle. Many mesoscopic folds
Potomac	North-northeast to north-northwest	Spaced schistosity, contains prograde minerals	Intersection with Captain Hickory schistosity	Tight to isoclinal, upright to overturned, similar folds. Fold both bedding and Captain Hickory schistosity. Control the map pattern in all but the southeastern part of the quadrangle
Captain Hickory	Apparently west or slightly north of west	Regional schistosity in Peters Creek Schist	Mineral lineation in higher-grade rocks and intersections of schistosity with bedding in Peters Creek Schist	Isoclinal, bedding nearly parallel to schistosity in most exposures. Small folds, intersection lineations and mineral lineations plunge down the dip of later foliations unless they have been rotated into parallelism with later fold axes

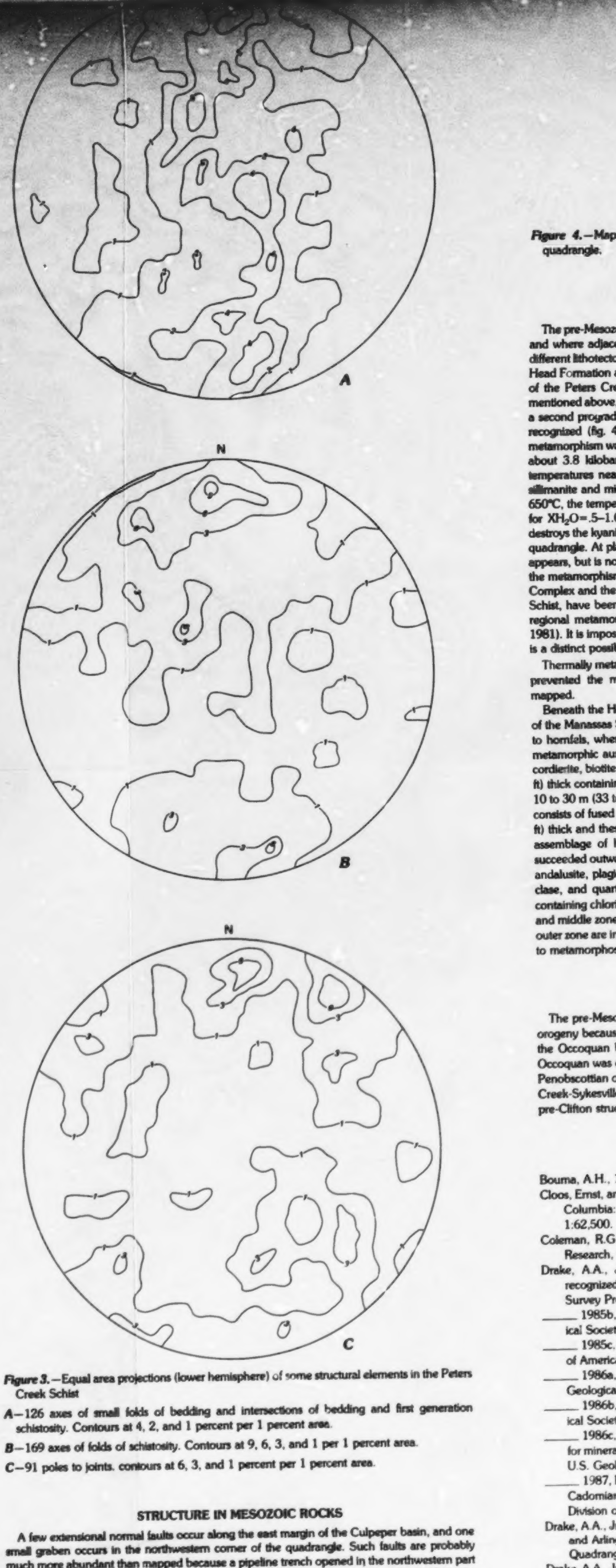


Figure 3.—Equal area projections (lower hemisphere) of some structural elements in the Peters Creek Schist

A—126 axes of small folds of bedding and intersections of bedding and first generation schistosity. Contours at 4, 2, and 1 percent per 1 percent area.

B—169 axes of folds of schistosity. Contours at 9, 6, 3, and 1 per 1 percent area.

C—91 poles to joints. contours at 6, 3, and 1 percent per 1 percent area.

STRUCTURE IN MESOZOIC ROCKS

A few extensional normal faults occur along the east margin of the Culpeper basin, and one small graben occurs in the northwestern corner of the quadrangle. Such faults are probably much more abundant than mapped because a pipeline trench opened in the northwestern part of the Vienna quadrangle in 1969 showed a sequence of such faults stepping down to the west. Poor exposure hinders the mapping of such faults, which have relatively small displacements.

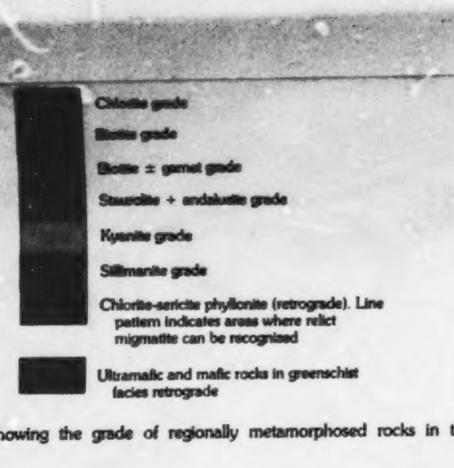

Chlorite grade
Biotite grade
Biotite ± garnet grade
Staurolite + andalusite grade
Kyanite grade
Sillimanite grade
Chlorite-sericite phyllonite (retrograde). Line pattern indicates areas where relict migmatite can be recognized
Ultramafic and mafic rocks in greenschist facies retrograde

Figure 4.—Map showing the grade of regionally metamorphosed rocks in the Vienna quadrangle.

METAMORPHISM

The pre-Mesozoic rocks within the Vienna quadrangle have been regionally metamorphosed, and where adjacent to the Herndon diabase sheet, thermally metamorphosed. Rocks of the different lithotectonic units have had different metamorphic histories (fig. 4). Rocks of the Popes Head Formation are at biotite grade and have undergone only one metamorphic event. Rocks of the Peters Creek Schist have had a much more complex metamorphic history. As was mentioned above, these rocks have undergone a major prograde event, a retrograde event, and a second prograde event. In this quadrangle, all the zones of the first prograde event can be recognized (fig. 4). The occurrence of andalusite, kyanite, and sillimanite suggest that this metamorphism was accomplished near the aluminum silicate triple point, that is at a pressure of about 3.8 kilobars (Holdaway, 1971). The highest-grade rocks are migmatitic, suggesting temperatures near the H_2O-saturated granite minimum; some specimens contain coexisting sillimanite and microcline. The maximum temperature of metamorphism was probably about 650°C, the temperature at which the second sillimanite isograd intersects the granite minimum for XH_2O=.5–1.0 (Kerrick, 1982). The chlorite-sericite retrograde zone as mapped largely destroys the kyanite- and sillimanite-zone mineral assemblages in the southern two-thirds of the quadrangle. At places, migmatite can be recognized by the presence of sheared leucosome. It appears, but is not certain, that the growth of new minerals within the phyllonite resulted from the metamorphism in the rocks of the Popes Head Formation. Rocks within the Piney Branch Complex and the Yorkshire Formation, as well as the ultramafic rocks within the Peters Creek Schist, have been metamorphosed to mineral assemblages stable in the greenschist facies of regional metamorphism and almost no relict original minerals survive (Drake and Morgan, 1981). It is impossible at this time to relate this metamorphism to that in the other rocks, but it is a distinct possibility.

Thermally metamorphosed rocks are not shown on figure 4 because the paucity of exposure prevented the mapping of the metamorphic zones. The thermal aureole, however, was mapped.

Beneath the Herndon diabase sheet, the more argillaceous rocks of the Poolesville Member of the Manassas Sandstone, as well as the Peters Creek Schist, are thermally metamorphosed to hornfels, whereas the sandy and conglomeratic rocks are altered to granofels. Within the metamorphic aureole, hornfels has an inner zone 2 to 5 m (6.5 to 16.5 ft) thick, containing cordierite, biotite, quartz, and plagioclase, succeeded by a middle zone 15 to 100 m (49 to 328 ft) thick containing cordierite, andalusite, plagioclase, and quartz, and finally by an outer zone 10 to 30 m (33 to 98.5 ft) thick containing chlorite, epidote, and quartz (Lee, 1982). Granofels consists of fused lenses, layers, and irregular masses. The inner metamorphic zone is 10 m (33 ft) thick and these rocks contain decussate biotite, plagioclase, and recrystallized quartz or an assemblage of hornblende, sodic plagioclase, titanite, and myrmekite-quartz. This zone is succeeded outward by a middle zone 16 m (52.5 ft) thick containing the assemblage cordierite, andalusite, plagioclase, and recrystallized quartz, or the assemblage black tourmaline, plagioclase, and quartz. This is surrounded by an outer zone 10 to 30 m (33 to 98.5 ft) thick, containing chlorite and epidote. These mineral assemblages suggest that the rocks in the inner and middle zones within the aureole are in hornblende-hornfels facies and that the rocks in the outer zone are in albite-epidote-hornfels facies. Temperatures apparently were not high enough to metamorphose these rocks in pyroxene-hornfels facies.

TIME OF DEFORMATION

The pre-Mesozoic deformation in the Vienna quadrangle is thought to predate the Taconic orogeny because this deformation is either synchronous with or predates the emplacement of the Occoquan batholith in Cambrian (probably Upper Cambrian) time (Drake, 1987). The Occoquan was emplaced synkinematically during Clifton folding. This deformation then was a Penobscottian or earlier event (Drake, 1987). Rocks of the Piney Branch-Yorkshire and Peters Creek-Sykesville motifs have experienced a much more complex geologic history and their pre-Clifton structures may date from the Cadomian orogeny.

REFERENCES CITED

Bouma, A.H., 1962, Sedimentology of some flysch deposits: Amsterdam, Elsevier, 168 p.

Cloos, Ernst, and Cooke, C.W. 1953, Geologic map of Montgomery County and the District of Columbia: Maryland Department of Geology, Mines, and Water Resources, scale 1:62,500.

Coleman, R.G., and Peterman, Z.E., 1975, Oceanic plagiogranite: Journal of Geophysical Research, v. 80, no. 8, p. 1099–1108.

Drake, A.A., Jr., 1985a, Tectonic implications of the Indian Run Formation—a newly recognized sedimentary melange in the northern Virginia Piedmont: U.S. Geological Survey Professional Paper 1324, 12 p.

_____ 1985b, Metamorphism in the Potomac composite terrane, Virginia-Maryland: Geological Society of America Abstracts with Programs, v. 17, no. 7, p. 566.

_____ 1985c, Sedimentary melanges of the central Appalachian Piedmont: Geological Society of America Abstracts with Programs, v. 17, no. 7, p. 566.

_____ 1986a, Geologic map of the Fairfax quadrangle, Fairfax County, Virginia: U.S. Geological Survey Geologic Quadrangle Map GQ-1600, scale 1:24,000.

_____ 1986b, Probable Late Proterozoic rocks of the central Appalachian Piedmont: Geological Society of America Abstracts with Programs, v. 18, no. 1, p. 14.

_____ 1986c, Field Trip to Potomac Gorge, *in* Cargill, S.M., and Green, S.B., eds., Prospects for mineral resource assessments on public lands—Proceedings of the Leesburg workshop: U.S. Geological Survey Circular 980, p. 328.

_____ 1987, Pre-Taconian deformation in the Piedmont of the Potomac Valley-Penobscotian, Cadomian, or both? *in* Contributions to Virginia Geology - VI (Harris Volume): Virginia Division of Mineral Resources Publication 74, 18 p.

Drake, A.A., Jr., and Froelich, A.J., 1986, Geologic map of the Annandale quadrangle, Fairfax and Arlington Counties, and Alexandria City, Virginia: U.S. Geological Survey Geologic Quadrangle Map GQ-1601, scale 1:24,000.

Drake, A.A., Jr., and Lyttle, P.T., 1981, The Accotink Schist, Lake Barcroft Metasandstone, and Popes Head Formation—keys to an understanding of the tectonic evolution of the northern Virginia Piedmont: U.S. Geological Survey Professional Paper 1205, 16 p.

Drake, A.A., Jr., and Morgan, B.A., 1981, The Piney Branch Complex—a metamorphosed fragment of the central Appalachian ophiolite in northern Virginia: American Journal of Science, v. 281, p. 484–508.

_____ 1983, Reply: Melanges and the Piney Branch Complex—a metamorphosed fragment of the central Appalachian ophiolite in northern Virginia: American Journal of Science, v. 283, no. 4, p. 376–381.

Drake, A.A., Jr., Sinha, A.K., Laird, Jo, and Guy, R.E., in press, The Taconic orogen, *in* Hatcher, R.D., Jr., Thomas, W.A., and Viele, G.W., eds., The Appalachian-Ouachita Orogen, U.S.: Boulder, Colorado, Geological Society of America, The Geology of North America, v. F-2.

Drake, A.A., Jr., Nelson, A.E., Force, L.M., Froelich, A.J., and Lyttle, P.T., 1979, Geologic map of Fairfax County, Virginia: U.S. Geological Survey Open-File Report 79–398, scale 1:48,000.

Fisher, G.W., 1963, The petrology and structure of the crystalline rocks along the Potomac River near Washington, D.C.: Baltimore, Md., The Johns Hopkins University, Ph.D. dissertation, 241 p.

_____ 1970, The metamorphosed sedimentary rocks along the Potomac River near Washington, D.C., *in* Fisher, G.W., and others, eds., Studies of Appalachian geology, central and southern: New York, Interscience, p. 299–315.

_____ 1971, The Piedmont crystalline rocks at Bear Island, Potomac River, Maryland: Maryland Geological Survey Guidebook 4, 32 p.

Froelich, A.J., 1975, Bedrock map of Montgomery County, Maryland: U.S. Geological Survey Miscellaneous Investigations Series Map I-920-D, scale 1:62,500.

Froelich, A.J., and Gottfried, David, in press, An overview of early Mesozoic intrusive rocks in the Culpeper basin, Virginia and Maryland, *in* Froelich, A.J., and Robinson, G.R., Studies of the early Mesozoic basins of the eastern United States: U.S. Geological Survey Bulletin 1776.

Froelich, A.J., and Olsen, P.E., 1984, Newark Supergroup, a revision of the Newark Group in eastern North America, *in* Contributions to stratigraphy: U.S. Geological Survey Bulletin 1537-A, p. A55-A58.

Ghosh, S.K., and Ramberg, Hans, 1968, Buckling experiments on intersecting fold patterns: Tectonophysics, v. 5, p. 89–105.

Gill, J.B., and Stork, A.L., 1979, Miocene low-K dacites and trondhjemites of Fiji, *in* Barker, Fred, ed., Trondhjemites, dacites and related rocks: Amsterdam, Elsevier Scientific Publishing Company, p. 629–649.

Holdaway, M.J., 1971, Stability of andalusite and the aluminum silicate phase diagram: American Journal of Science, v. 271, p. 97–131.

Hopson, C.A., 1964, The crystalline rocks of Howard and Montgomery Counties, *in* The geology of Howard and Montgomery Counties: Baltimore, Md., Maryland Geological Survey, p. 27–215.

Kerrick, D.M., 1982, Experimental determination of muscovite + quartz stability with $P_{H_2O} < P_{total}$: American Journal of Science, v. 272, p. 946-958.

Lee, K.Y., 1982, Thermal metamorphism of Triassic and Jurassic sedimentary rocks in the Culpeper basin, Virginia: Geological Society of America Abstracts with Programs, v. 14, no. 1 and 2, p. 34.

Lee, K.Y., and Froelich, A.J., 1989, Triassic-Jurassic stratigraphy of the Culpeper and Barboursville basins, Virginia and Maryland: U.S. Geological Survey Professional Paper 1472, p. 12–16.

Morgan, B.A., 1977, The Baltimore Complex, Maryland, Pennsylvania, and Virginia, *in* Coleman, R.G. and Irwin, W.P., eds., North American Ophiolites: Oregon Department of Geology and Mineral Industries Bulletin 95, p. 41–49.

Mose, D.G., and Nagel, M.S., 1982, Plutonic events in the Piedmont of Virginia: Southeastern Geology, v. 23, no. 1, p. 25-39.

Muth, K.G., Arth, J.G., and Reed, J.C., Jr., 1979, A minimum age for the high-grade metamorphism and granite intrusion in the Piedmont of the Potomac River gorge near Washington, D.C.: Geology, v. 7, no. 7, p. 349–350.

Mutti, Emiliano, and Ricci Lucchi, F.R., 1978, Turbidites of the northern Apennines—Introduction to facies analysis: Falls Church, Va., American Geologic Institute Reprint Series 3, p. 127–166.

Nockolds, S.R., 1954, Average chemical compositions of some igneous rocks: Geological Society of America Bulletin, v. 65, p. 1007–1032.

O'Connor, J.T., 1965, A classification for quartz-rich igneous rocks based on feldspar ratios: U.S. Geological Survey Professional Paper 525B, p. B79-B84.

Rankin, D.W., Drake, A.A., Jr., and Ratcliffe, N.M., in press, Geologic map of the U.S. Appalachians showing the Laurentian margin and Taconic orogen, *in* Hatcher, R.D., Jr., Thomas, W.A., and Viele, G.W., eds., The Appalachian-Ouachita Orogen, U.S.: Boulder, Colorado, The Geological Society of America, The Geology of North America, v. F-2.

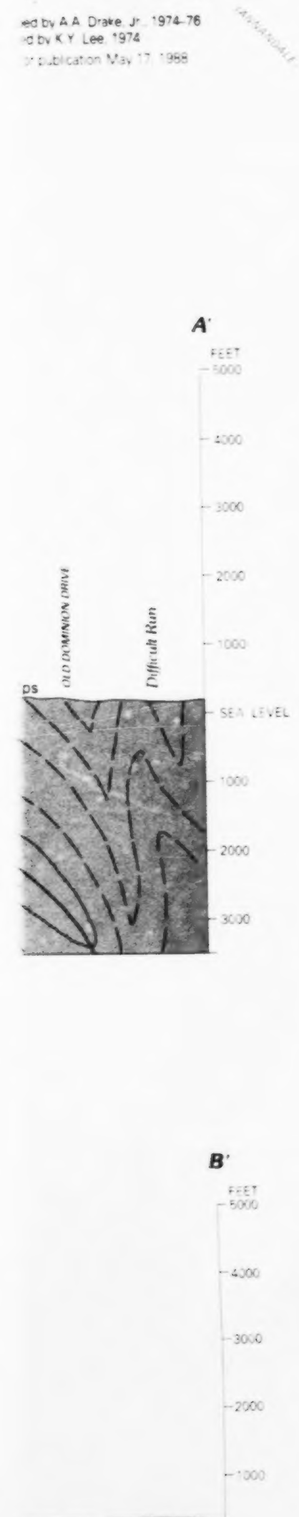
Reed, J.C., Jr., Marvin, R.F., and Mangum, J.H., 1970, K-Ar ages of lamprophyre dikes near Great Falls, Maryland-Virginia: U.S. Geological Survey Professional Paper 700-C, p. C145-C149.

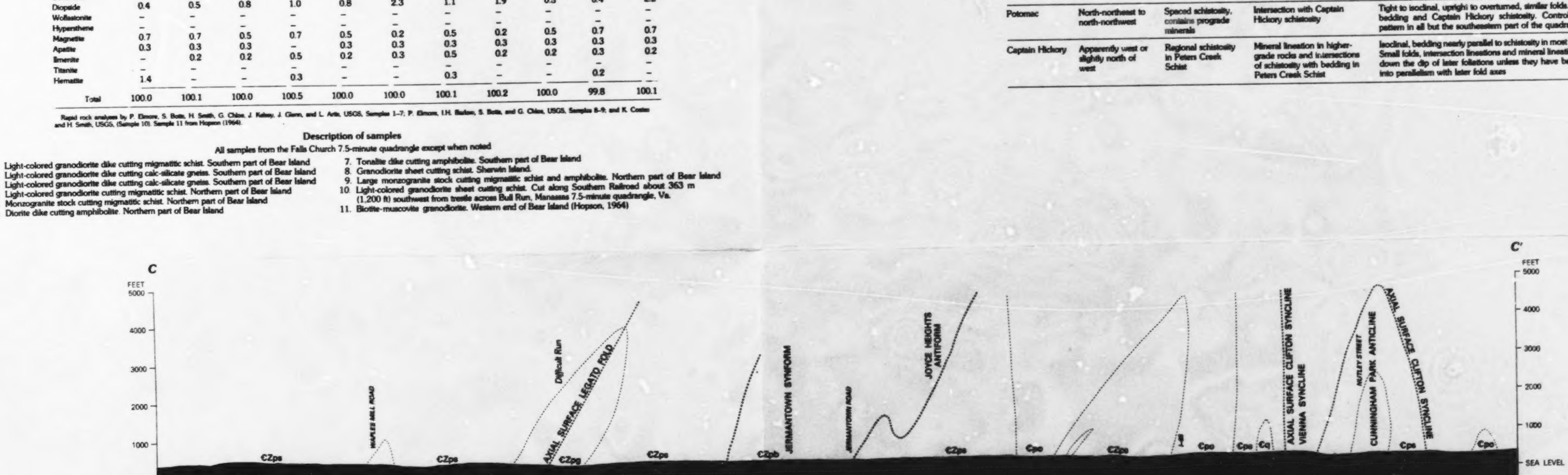
Seiders, V.M., Mixon, R.B., Stern, T.W., Newell, M.F., and Thomas, C.B., 1975, Age of plutonism and tectonism and a new minimum age limit on the Glenarm Series in the northeast Virginia Piedmont near Occoquan: American Journal of Science, v. 275, no. 5, p. 481–511.

Streckeisen, Albert, 1976, To each plutonic rock its proper name: Earth Science Reviews, v. 12, p. 1–33.

Sutter, J.F., 1985, Progress on geochronology of Mesozoic diabase and basalts, *in* Proceedings of the Second U.S. Geological Survey Workshop on the early Mesozoic basins of the eastern United States: U.S. Geological Survey Circular 945, p. 110–114.

Tobisch, O.T., and Fleuty, M.J., 1969, Use of geographic names for successive fold phases in areas of multiple folding: Geological Society of America Abstracts with Programs, v. 7, pt. 7, p. 225–226.





1000 feet = 305 meters
Surficial deposits not shown on section

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA.—1989

LOGIC MAP OF THE VIENNA QUADRANGLE, FAIRFAX COUNTY, VIRGINIA, AND MONTGOMERY COUNTY, MARYLAND

By
Avery Ala Drake, Jr., and K.Y. Lee
1989

For sale by U.S. Geological Survey Map Distribution, Box 25286, Federal Center, Denver, CO 80225

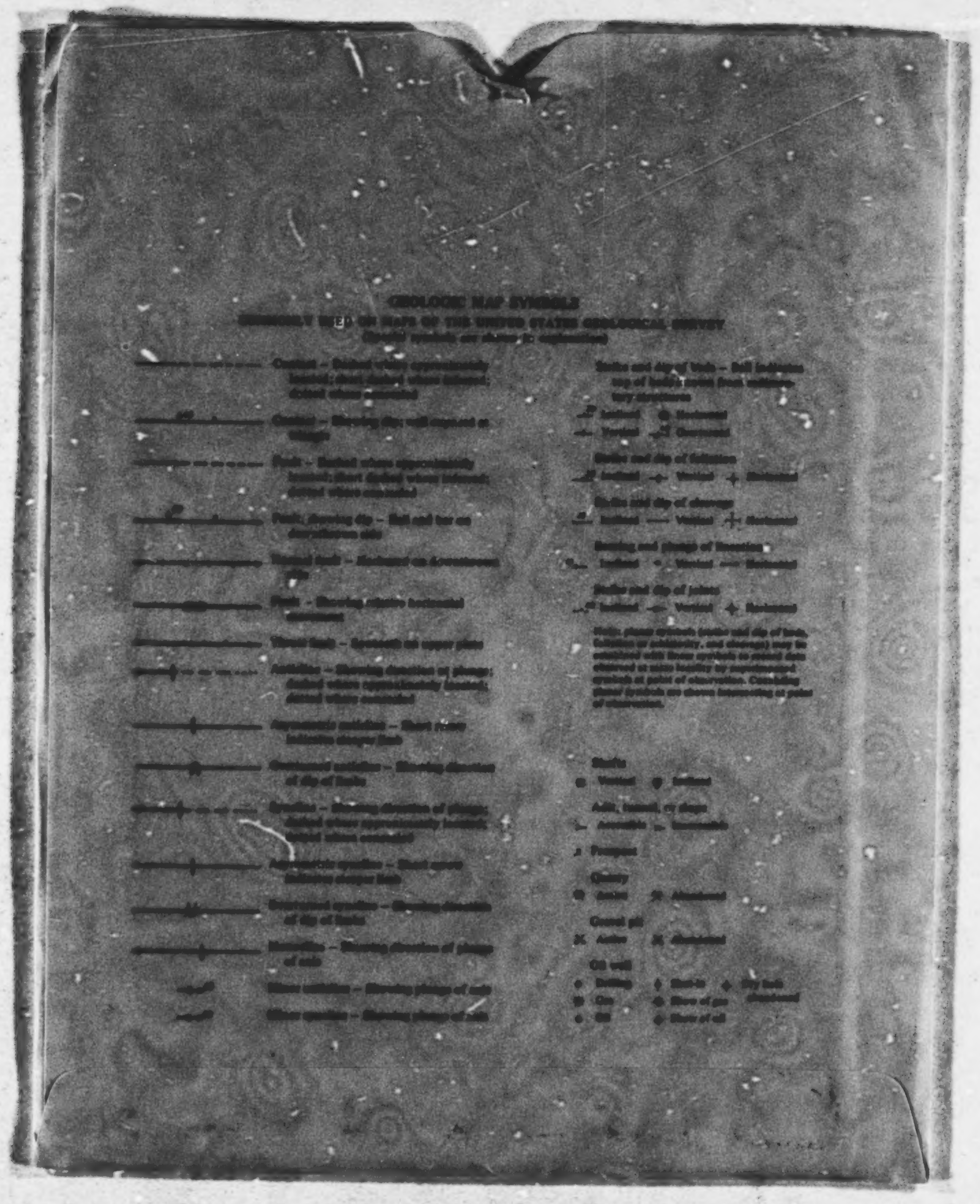
MAP GQ-1670

DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

GEOLOGIC MAP OF THE VIENNA QUADRANGLE, FAIRFAX COUNTY, VIRGINIA, AND MONTGOMERY COUNTY, MARYLAND

By Avery Ala Drake, Jr., and K.Y. Lee

GEOLOGIC QUADRANGLE MAP
Published by the U.S. Geological Survey, [illegible]



GEOLOGIC MAP SYMBOLS

COMMONLY USED ON MAPS OF THE UNITED STATES GEOLOGICAL SURVEY

(Special symbols are shown in explanation)

Contact – Dashed where approximately located; short dashed where inferred; dotted where concealed

Contact – Showing dip; well exposed at triangle

Fault – Dashed where approximately located; short dashed where inferred; dotted where concealed

Fault, showing dip – Ball and bar on downthrown side

Normal fault – Hachured on downthrown side

Fault – Showing relative horizontal movement

Thrust fault – Sawteeth on upper plate

Anticline – Showing direction of plunge; dashed where approximately located; dotted where concealed

Asymmetric anticline – Short arrow indicates steeper limb

Overturned anticline – Showing direction of dip of limbs

Syncline – Showing direction of plunge; dashed where approximately located; dotted where concealed

Asymmetric syncline – Short arrow indicates steeper limb

Overturned syncline – Showing direction of dip of limbs

Monocline – Showing direction of plunge of axis

Minor anticline – Showing plunge of axis

Minor syncline – Showing plunge of axis

Strike and dip of beds – Ball indicates top of beds known from sedimentary structures

Inclined ⊕ Horizontal

Vertical Overturned

Strike and dip of foliation

Inclined Vertical Horizontal

Strike and dip of cleavage

Inclined Vertical Horizontal

Bearing and plunge of lineation

Inclined Vertical Horizontal

Strike and dip of joints

Inclined Vertical Horizontal

Note: planar symbols (strike and dip of beds, foliation or schistosity, and cleavage) may be combined with linear symbols to record data observed at same locality by superimposed symbols at point of observation. Coexisting planar symbols are shown intersecting at point of observation.

Shafts

Vertical Inclined

Adit, tunnel, or slope

Accessible Inaccessible

Prospect

Quarry

Active Abandoned

Gravel pit

Active Abandoned

Oil well

Drilling Shut-in Dry hole abandoned

Gas Show of gas

Oil Show of oil